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STUDENT-TEACHER POPULATION GROWTH MODEL--DYNAMOD II.

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DYNAMOD II IS A COMPUTERIZED MARKOVIAN-TYPE FLOW MODEL DEVELOPED TO PROVIDE ESTIMATES OF THE EDUCATIONAL POPULATION OF STUDENTS AND TEACHERS OVER SELECTED INTERVALS OF TIME. THE POPULATION IS CROSS-CLASSIFIED INTO 108 GROUPS BY SEX, RACE, AGE, AND EDUCATIONAL CATEGORY. THIS NOTE DESCRIBES THE METHODOLOGY USED IN DYNAMOD II, COMPARES DYNAMOD II STUDENT AND TEACHER PROJECTIONS TO 1970, AND AGE, SEX, AND RACE PROJECTIONS WITH THOSE OF THE OFFICE OF EDUCATION, AND MAKES SPECIAL ANALYSES OF BIRTH VARIATIONS, VARIATIONS IN RETENTION RATES OF STUDENTS AND TEACHERS, AND STUDENT-TEACHER RATIOS. INCLUDED AMONG THE MORE IMPORTANT FINDINGS ARE--(1) DYNAMOD II IS A SUITABLE REPRESENTATION OF THE EDUCATIONAL POPULATION FOR PLANNING PURPOSES, (2) THE MODEL IS USEFUL FOR EXPLORING THE EFFECTS OF CHANGES IN THE BIRTH AND DEATH RATES IN THE EDUCATIONAL POPULATION, (3) THE MODEL IS USEFUL FOR EXAMINING THE IMPACT ON THE EDUCATIONAL POPULATION OF POLICIES DESIGNED TO KEEP MORE STUDENTS IN SCHOOL, (4) THE GREATEST IMPACT OF A CHANGE IN STUDENT RETENTION OCCURRED IN THE COLLEGE SECTOR, (5) THE TEACHING SECTOR WAS FOUND TO BE MORE SENSITIVE TO CHANGES IN RETENTION RATES THAN THE STUDENT SECTOR, AND (6) STUDENT-TEACHER RATIOS WERE FOUND TO BE MORE SENSITIVE TO CHANGES IN THE TEACHER RETENTION RATES THAN WERE STUDENT RETENTION RATES. (HW)

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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NATIONAL CENTER FOR EDUCATIONAL STATISTICS
Division of Operations Analysis

Student-Teacher Population Growth
Model: DYNAMOD II

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HIGHLIGHTS OF THE REPORT

DYNAMOD II is a computerized Markovian-type flow model developed to provide estimates of the educational population of students and teachers over selected intervals of time. The population is cross-classified into 108 groups by sex, race, age, and educational category i.e., elementary school student, elementary school teacher, etc. These groups are listed in Appendix E.

Among the more important findings in the report (and subject to final validation), it can be said that:

1. DYNAMOD II is a suitable representation of the educational population for planning purposes;
2. The model is useful for exploring the effects of changes in the birth and death rates on the educational population;
3. The model is useful for examining the impact on the educational population of policies designed to keep more students in school. For example, if policymakers wish to examine the population effects of a program that is expected to raise the retention rate of secondary school students by one percent (i.e., keep in secondary school one more student per hundred than has been the case), the model can be readily adapted to produce new projections incorporating these requirements. By comparing the new projections of the secondary school population to the old, a measure of the impact of the policy is produced;
4. The greatest impact of a change in a student retention rate occurred in the college sector, where the introduction of a one percent

increase in the retention rate in 1959-60 would have increased the number of college students by three percent in 1969-70. Similar changes to the retention rates of elementary and secondary school students produced increases of one and over two percent, respectively, in those populations;

5. The teaching sector was found to be more sensitive to changes in retention rates than the student sector, and thereby seems to constitute a potentially fruitful target for policy. In all three teaching levels (elementary, secondary and college), the increase in the respective population brought on by a one percent increase in the retention rates during the 1959-60 school year would have exceeded 4.7 percent by 1969-70;
6. Student-teacher ratios were found to be more sensitive to changes in the teacher retention rates than was the case for student retention rates. This suggests that, in cases where the student-teacher ratio is deemed to be too high, but an increase in the number of students in the system is desirable over the long term, a suitable policy to control the level of the ratio would be to first increase the retention rates of teachers, and then pursue policies to increase the retention rates of students.

Student-Teacher Population Growth Model: DYNAMOD II

INTRODUCTION

Historical Background

In September, 1966, an unpublished paper entitled, "DYNAMOD I: A Research Demographic Model," was written. It demonstrated the feasibility of applying Markov chain analysis to problems of the growth and composition of the educational population of students and teachers.

DYNAMOD II was developed on the basis of the lessons learned from DYNAMOD I. It is a more finely structured and consequently more accurate model than was DYNAMOD I. As such, DYNAMOD II should prove to be of use to Office of Education planners and analysts for examining the impact of policy alternatives on the educational population.

This report contains some illustrations of the means by which the aforementioned impacts can be estimated. The next report, which will implement numerous small improvements to the model's accuracy, will contain more examples of the effects of different policy alternatives, and will examine the effects in more depth than is appropriate in an initial report.

As useful as DYNAMOD II should prove to be, it falls short of the ultimate goal in model building. That is, ideally it is desirable to have the population flows follow the "real world" as closely as possible. A model now being developed, the Student-Teacher Analysis of Growth Model (STAG), will approach this ideal. "STAG" will contain educational

population flows by single years of age and single grades.

DYNAMOD II approximates the standard population projections of the Office of Education and Bureau of the Census well enough to provide educational planners, analysts, and policymakers with "order of magnitude" estimates of the effects of variations in certain key items, such as student and teacher retention rates or birth rates, until STAG becomes operational.

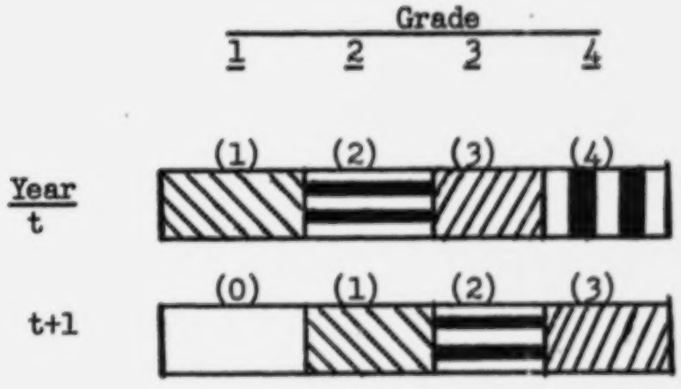
Markov Processes in General

By way of a brief summary or an introduction to Markov processes, one may think of them as follows:

1. There is a sequence of operations over a period of time, such as a group of students flowing through a school system;
2. There are a finite number of outcomes for the operations--for example, a student either is in school or not; if he is in school, he must be in a particular grade or school level, i.e., all of his possible "states" must be identifiable and countable;
3. All the information required to determine the workings of the process is knowledge of the last set of outcomes and their respective probabilities.

Consider, for example, the simplified Markov process below. In year t, there are students in each grade of a four-grade system, designated (1) through (4), respectively. Assuming no deaths, no repeaters, and equal class sizes, it is noted that, by year t+1, group (4) has left

the system, groups (1), (2), and (3) remain, and a new group of students designated (0), appear in grade 1. The latter group previously were not in school, and the total number of children not in school in year t is known.



Since the requirements of a Markov process are satisfied, the description of this flow network can be put in matrix form, using coefficients called "transition probabilities" to mathematically describe the flow patterns:

Year t+1

Year t	In school	Not in school	Sum
In school	$\frac{(1)+(2)+(3)}{(1)+(2)+(3)+(4)} = .75$	$\frac{(4)}{(1)+(2)+(3)+(4)} = .25$	1.00
Not in school	$\frac{(0)}{(\text{Total not in school}_t)} = X$	$1.00 - X$	1.00

The probability in the upper left hand corner, i.e., the probability of a student who was in school in year t being in school in year t+1, is estimated from the grade flows above. It is also called a "retention rate," a phrase used frequently in this report. The probability of an

enrollment is calculated by taking the ratio of enrollments in year t+1 to the total number not enrolled in year t. The other estimates are made accordingly, subject to the restriction that each row must sum to one.

With the probabilities identified, and subject to the other previously-mentioned assumptions, all that remains to be known is the respective number of children in school and not in school in year t. With that information, the population of school children can be predicted for any year in the future by cycling the population through the matrix the desired number of times (providing, of course, that the fundamental conditions underlying the projections do not change.)

Markov Processes and DYNAMOD II

The above description can be considered to be a sketch of the way DYNAMOD II operates. Of course, a large computer model which grapples with the complexities of reality must be, of itself, complex. Nevertheless, DYNAMOD II provides a capability for analysis not easily filled by other means. For example, estimates of the numbers of people in educational policy target populations (such as young nonwhite boys in secondary school) are available in DYNAMOD II, but not elsewhere, because that type of data is not collected in such detail in most surveys. The 1960 Census of Population collected such information, however, and, in conjunction with estimates of transition probabilities to describe the flows and cross-flows of the population, provided the means for making projections of the numbers in those groups for a predetermined number of years.

Furthermore, by hypothesizing the effects that policy changes would

have on the transition probabilities, an assumed impact on the population can be quantified.

Actually, DYNAMOD II is not a true Markov process, at least in the conventional sense. One might best consider DYNAMOD II as a Markov process superimposed over a growth function representing net births. In a conventional Markov process, one has the alternatives of either cycling the basic population vector, P, n times through the transition matrix T, or calculating $P(T^n)$ to determine the distribution of the various population groups in year n, where (T^n) is the n th power of the matrix T. The occurrence of net births in the model prevents the use of the second alternative, even if it were desired--but the population groups in DYNAMOD II must be cycled each time, to get annual data.

Basic Assumptions

The basic assumptions used in DYNAMOD II are as follows:

1. Death rates are fixed during the projection interval;
2. The transition probabilities are fixed during the projection interval;
3. A Markov-type process is a suitable means for representing the flows of people among categories.

Scope of Data

DYNAMOD II is in every sense a large population model. It features a population divided into:

- elementary school students
- secondary school students
- college students
- elementary school teachers
- secondary school teachers
- college teachers
- other (i.e., persons who are neither students nor active teachers)

The population is further divided by sex and race (i.e., white and nonwhite), and into age levels 0-4, 5-14, 15-19, 20-24, 25-44 and 44 years or older. In all, there are 108 separate population groups (including deaths) in DYNAMOD II, which required the estimate of 656 separate probabilities to describe the groups' crossflows among categories. A listing of the groups is given in Appendix E.

The student and teacher data are centered on the academic year beginning in September. The remainder of the population is centered on April of the following year.

The data for students and teachers include both public and nonpublic schools, but not schools such as residential schools for exceptional children, subcollegiate departments of institutions of higher education, Federal schools for Indians, or schools in Federal installations. Since the data from the Bureau of the Census' 1/1,000 sample were forced into agreement (see "Methodology" below) with those published by the Office of Education[1/], Office of Education definitions are applicable.

Elementary school students are defined in this note to be those children in kindergarten through grade 8, and secondary school students are those in grades 9 through 12. College student figures apply to opening fall degree-credit enrolled students, full time and part time. The full-time-equivalent concept was not used for students.

The three teacher categories (elementary, secondary and college) are also aligned with Office of Education definitions, except that, as

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1/ U.S. Department of Health, Education, and Welfare, Office of Education, Projections of Educational Statistics to 1974-75, OE-10030-65 (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1965).

with students, full time equivalents were not calculated.

It should be noted that grade-wise, the elementary and secondary school teacher categories are not directly comparable to the respective student categories. That is, a proportion of teachers in grades 7 and 8 are actually classified as secondary for Office of Education definitional purposes. The effects of these differences on the student-teacher ratios are discussed on page 46 below.

Methodology

The following paragraphs summarize the methodology employed in the development of DYNAMOD II. More detailed discussions of the specific procedures employed have been or will be issued in other technical notes.

Population inputs. The primary data base for the population inputs to DYNAMOD II was the information available on the Bureau of the Census' 1/1,000 sample data tape from the 1960 Census of Population. Sampling error, response error and definitional differences were sufficiently large in some cases to require manual adjustments to the distributions before they were considered to be acceptable as inputs to the model. For example, students who were part time teachers sometimes reported themselves as both students and teachers, and vice versa. The redistribution of these overlaps first had to be resolved. Then, the tape distributions for aggregate categories such as age or elementary students had to be reconciled with the Bureau of the Census' distributions as published. Finally, the adjusted data were readjusted to force the student and teacher totals into agreement with published Office of Education totals.

Births. Birth projections in absolute numbers by sex and race were used in the model, as opposed to the rate concept used for deaths (see "Death rates" below). Two sets of birth data were utilized in DYNAMOD II. The first was Series "B" as published by the Bureau of the Census.[2] These data provided information on the numbers of births by race. Estimates of the within-race male-female distributions, not published in that document, were made within the Division of Operations Analysis.[3]

The second set of birth projections used in DYNAMOD II were independently estimated (appendix table B-1).[4] It was felt that there was a distinct need for an independent set of estimates, because, while Office of Education projections are largely keyed to Series "B" births, there was a marked discrepancy between the published Series "B" data and the births actually being realized in the population. The results for both sets of birth projections variants are presented later in this report. To maintain a constant reference comparison, however, the Series "B" data have been used in the DYNAMOD II base-line projections,

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2/ U.S. Bureau of the Census, Current Population Reports, Population Estimates, Series P-25, No. 345, "Projections of the White and Nonwhite Population of the United States, by Age and Sex, to 1985," July 29, 1966.

3/ The proportions used to allocate male and females within the races were the same as those shown in paper by T. Okada, "Birth and Death Projections Used in Present Student-Teacher Population Growth Model," Technical Note No. 11, December 14, 1966.

4/ Ibid.

as well as in the projections where the student or teacher retention rates have been varied.

Death Rates

Wherever applicable, death rates described in TN-11 were modified for DYNAMOD II to make use of differential mortality rates by occupation.[5] For male teachers, separate mortality rates were obtained for both white and nonwhite from mortality rates based on occupation and age grouping. Their female counterparts were derived by assuming that the female teacher population exhibited the same male-to-female mortality ratios as in the general population.[6]

Mortality rates for college students in the 15-19 year age interval were assumed to be the same as for teachers in the 20-24 year interval, which are less than those for the general population of 15-19 year olds. College students in the remaining age intervals were assumed to have the same death rates as teachers. For elementary and secondary students, death rates used in the model were those for the general population. (See appendix table B-6 for the death rates actually used in DYNAMOD II.)

5/ U.S. Department of Health, Education, and Welfare, Public Health Service, National Vital Statistics Division, "Mortality by Occupation and Industry Among Men 20 to 64 Years of Age: United States, 1950," Vital Statistics-Special Reports, Vol. 53, No. 2, Sept., 1962. (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office), table 2.

6/ U.S. Department of Health, Education, and Welfare, Public Health Service, National Center for Health Statistics, Vital Statistics of the United States, Vol. II - Mortality, Part A. (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office), table 1-25.

Estimates of transition probabilities. Detailed discussions of the procedural methods used to estimate the model's transition probabilities will be described in other analytical notes to be issued shortly. The estimating procedures can be summarized briefly as follows:

1. First approximations to the probabilities for males and females were developed from whatever data sources could be utilized, as well as from theoretical and empirical knowledge of the problem.

2. The male and female transition probability matrices were then adjusted by iterating the population several times, comparing the results to reference data, adjusting the probabilities, reiterating, etc., until the fit to the reference data was deemed acceptable.

3. Next, the male-female transition probability estimates were "factored" into their four respective age-race transition matrices. For example, the male elementary school student retention probability was divided into the retention rates for those white and nonwhite students who were 0-4, 5-14, 15-19, 20-24, and 25-44 years of age, respectively. The original estimates of the age-education transition probabilities were completely mechanical. Thus, selected manual adjustments to render these estimates logically acceptable were required before computerized iterations could take place. As an example, consider the fact that the probability of a 0-4 year old child becoming 5-14 years old next year is roughly .2. In initial calculations, .2 would be multiplied by the probability of remaining an elementary school student. However, the probabilities of age and educational status are not independent, at least at the extreme ends of the age distributions. In fact, the

probability of a child who is now a 0-4 year old elementary school student becoming a 5-14 year old elementary school student next year is actually quite high, because nearly all 0-4 year old elementary school students are 4 years old. This meant that the original estimate would have to be adjusted to account for the lack of statistical independence. The remaining probabilities in the matrices were screened in this manner and adjusted when necessary.

4. Finally, the four large matrices were used to iterate the population, primarily by computer calculations. After each iteration, the results were checked with the reference data. Because of the large number of coefficients involved, the initial corrections were made to the white males matrix, with manual iterations made to that group to determine whether or not the approximate degree of correction desired was being achieved. The next step was to change the coefficients of the other three matrices proportionately and recompute the 10-year projections. This process was continued until the projections all fell within 10 percent of the desired 1970 figures.

Calculating procedures. The calculating procedures used in the DYNAMOD II computer program are basically the same as those used in DYNAMOD I, Stage 2, with some minor changes in the statements specifying the way the output will be printed. The computer program is written in FORTRAN language for processing on an RCA 3301 computer.

All input data, that is, the transition probabilities, births, and population group totals are punched on cards. The program provides that multiplications by zero will not take place, since the density

of nonzero cells in the matrix is only about .25. The calculating rules in the program first read the feasible transition probabilities into storage, and then separately read in the numbers in the respective population groups. Next, the population groups are "scattered" by means of the probability coefficients into various receiver categories. All the receiver cells in a respective category are then summed to produce the new population category total, which then becomes the input number for the next year. Each population group is printed out for each year, and in addition, selected category totals (e.g., all elementary school students) are also printed out.[7/] The process is cycled for a predetermined number of years.

7/ Only the broader categories, such as all elementary or secondary school students, are presented in this report, but the printout contains completely detailed group estimates, for example, 5-14 year old nonwhite male elementary school students. These data will be available in the final report. See appendix E for a listing of the population groups presently used in DYNAMOD II.

PRELIMINARY RESULTS

Presented below is a discussion of the results of the preliminary computer runs for DYNAMOD II. The results of the DYNAMOD II projections are compared to projections produced elsewhere within the Office of Education, or where applicable, to projections published by the Bureau of the Census.[8/]

Some terminological differences are present between DYNAMOD II terms and those used elsewhere in the Office of Education. In DYNAMOD II, the term "elementary school students" (or teachers) refers to the kindergarten-through-grade 8 grouping, while in the Office of Education, the term refers to those who are grouped specifically in elementary schools, and does not include those of grade 8 and below attending junior or senior high schools. Similarly, "secondary school students" (or teachers) in DYNAMOD II are in the grade 9-through-12 grouping. College students are defined in this report to be all degree-credit enrolled students, full or part time, graduate and undergraduate. College teachers include all instructional staff for resident degree-credit courses in institutions of higher education.

Student Projections, 1959-60 to 1969-70

The DYNAMOD II projections of elementary school students are

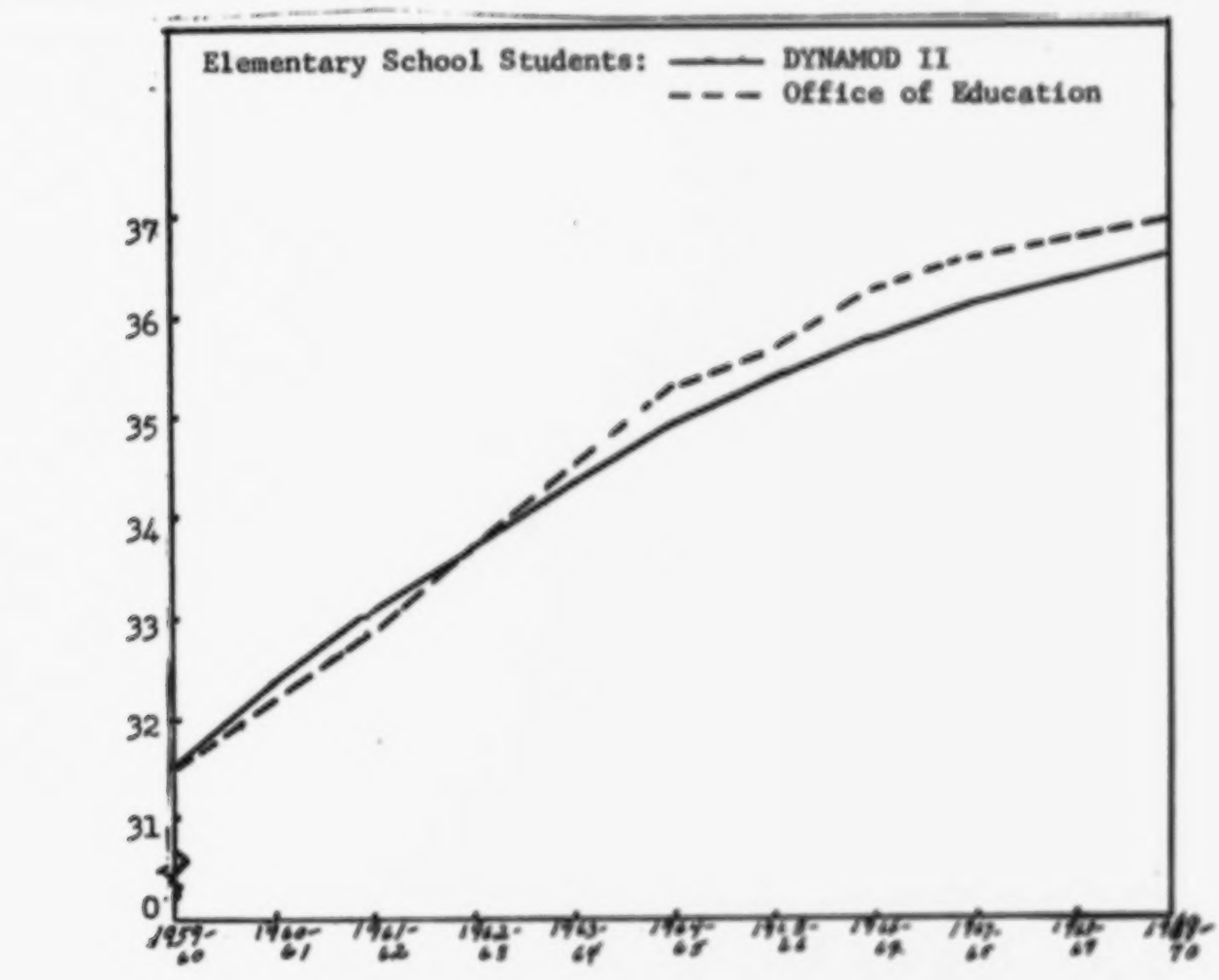
8/ The Office of Education projections used for the comparisons were published in U.S. Department of Health, Education, and Welfare, Office of Education, Projections of Educational Statistics to 1974-75, 1965 Edition, OE-10030-65 (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office). The primary reference document for comparing DYNAMOD II projections to those of the Bureau of the Census is U.S. Department of Commerce, Bureau of the Census, Population Estimates, Series P-25, No. 286.

slightly lower than those projections made by the Office of Education (figure 1). The largest difference is 1.3 percent, occurring both in 1966-67 and in 1967-68. In 1969-70 this figure drops to .9 percent. The percent differences mentioned in this discussion are found in the "A" appendix tables.

DYNAMOD II projections of secondary school students are graphically compared with Office of Education projections in figure 2. DYNAMOD II projections are again somewhat lower than those of the Office of Education, the difference being 8.1 percent in 1969-70. Because DYNAMOD II uses grouped age categories rather than single years of age, any increase in the number of students (or teachers) caused by the sudden appearance of a disproportionately large number of people of a particular age tends to be smoothed out over time. An example of this is seen in figure 2. The line representing Office of Education projections of secondary school students "peaks" in 1964-65, while the DYNAMOD II line indicates a more steady increase over the projection years.

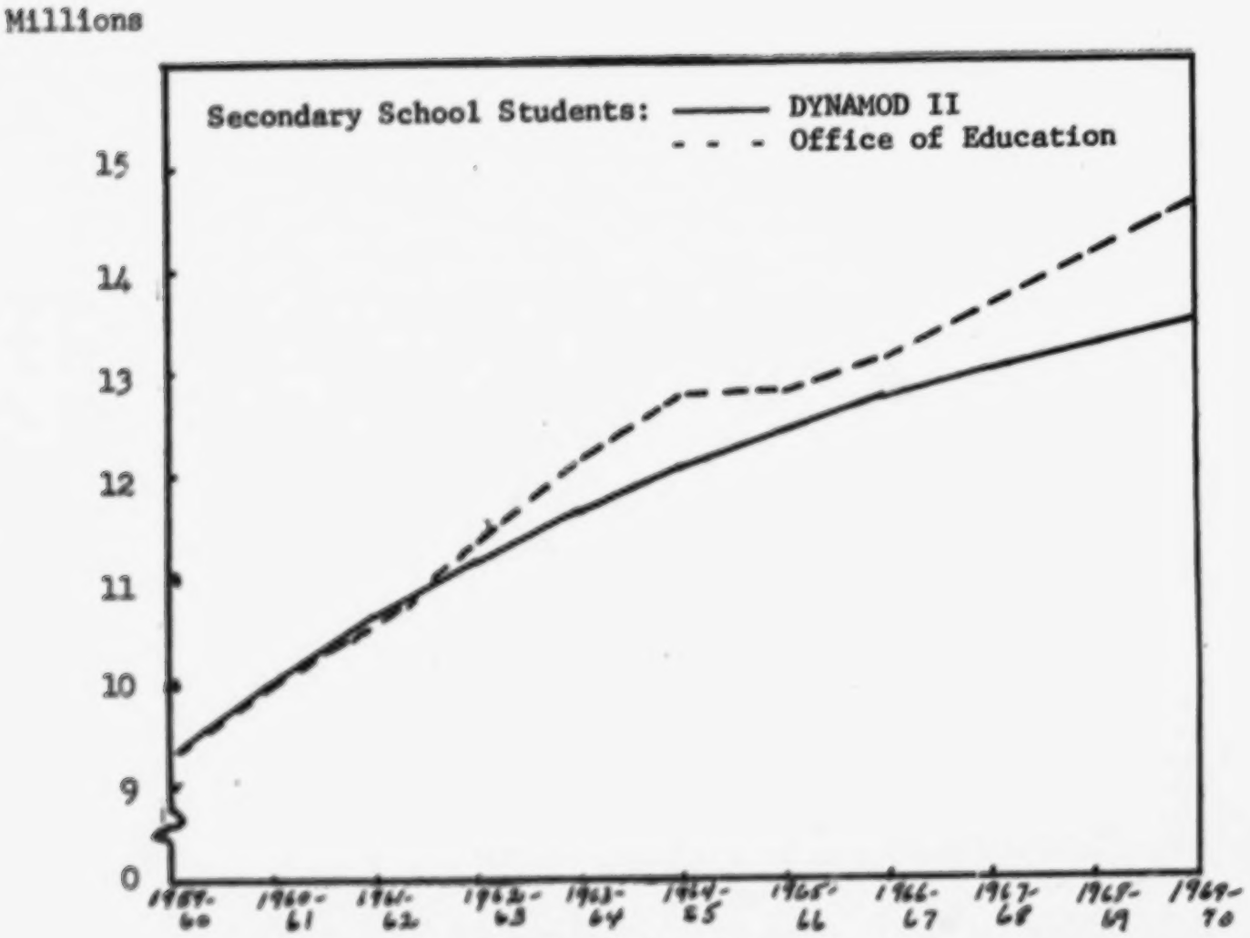
Figure 3 shows DYNAMOD II projections of college students greater than those of the Office of Education for the years 1960-61 to 1965-66. In 1966-67 DYNAMOD II falls 2.9 percent below the Office of Education projections, with the difference increasing to 7.9 percent in the 1968-69 academic year, then tapering to 6.5 percent in 1969-70. These differences in large part can be attributed to the interaction of the flows within the DYNAMOD II structure. For the early years of the projection interval, DYNAMOD II was close to or on the high side of the Office of Education reference projections of secondary school and college

Figure 1.-DYNAMOD II projections of elementary school students as compared with Office of Education projections, 1959-60 to 1969-70



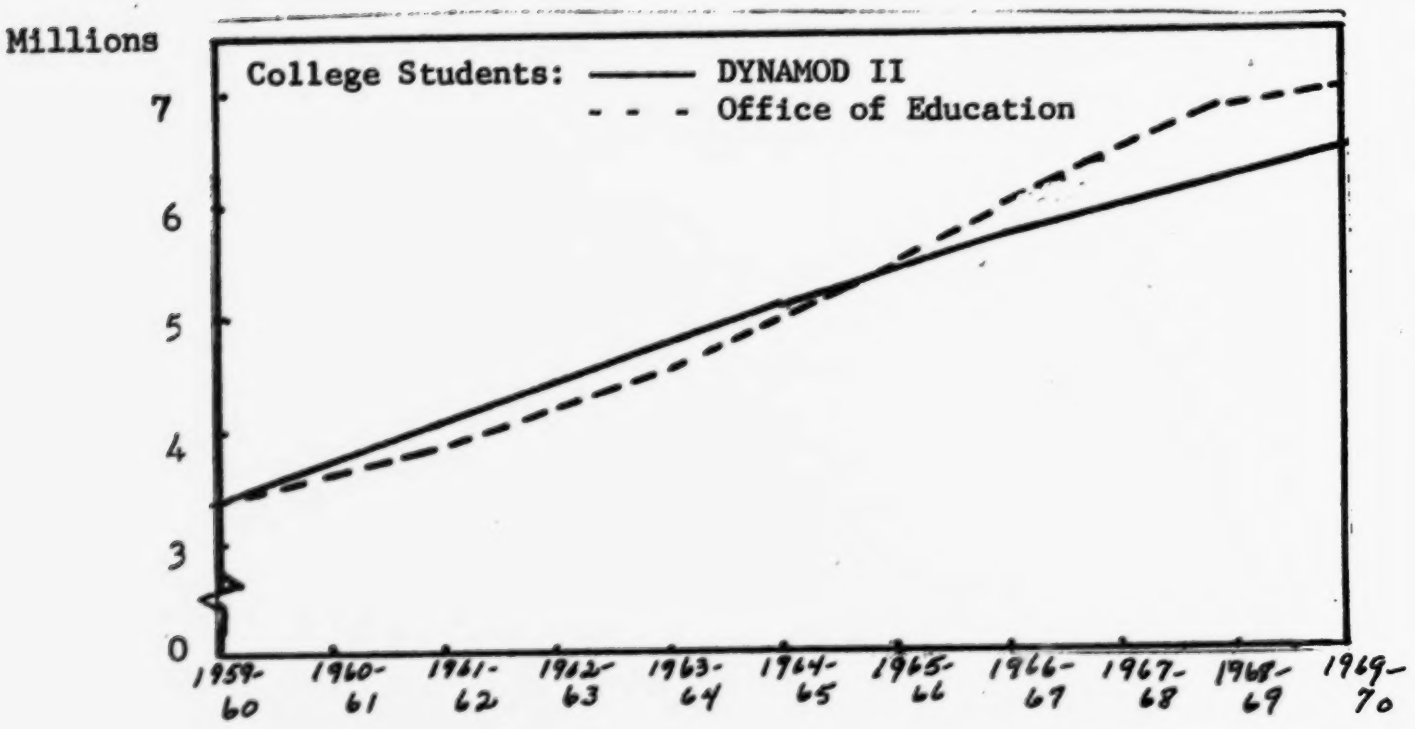
Source: Appendix table A-1

Figure 2.-DYNAMOD II projections of secondary school students as compared with Office of Education projections, 1959-60 to 1969-70



Source: Appendix table A-1

Figure 3 .-DYNAMOD II projections of college students as compared with Office of Education projections, 1959-60 to 1969-70



Source: Appendix table A-1

students. In the years beyond 1964-65, DYNAMOD II underestimated secondary school students to a greater degree than was the case for college students. This resulted in too few secondary school students being transferred to the college sector, hence the increase in the underestimate of college students in the last few years of the projection interval.

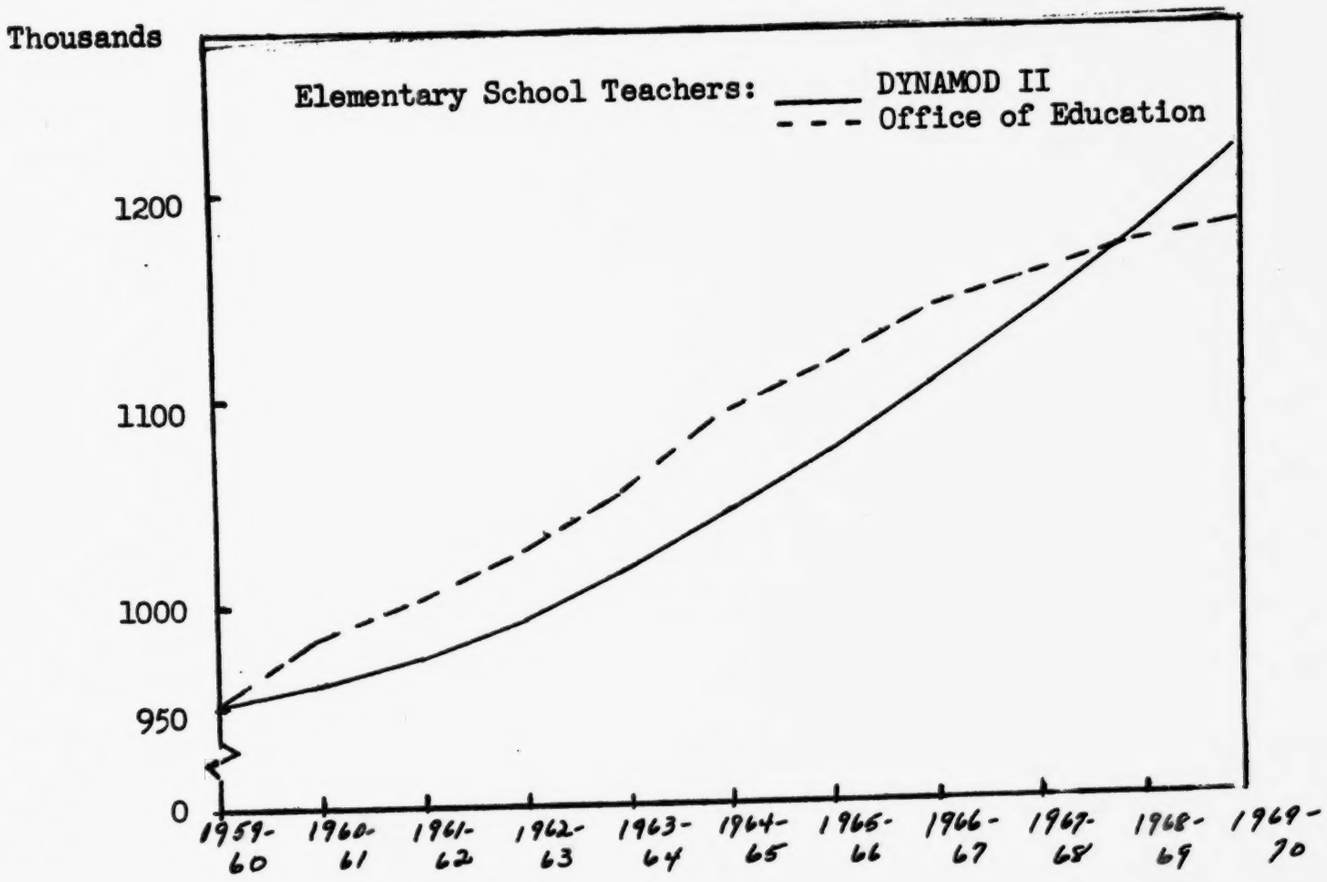
Teacher Projections, 1959-60 to 1969-70

DYNAMOD II projections of elementary school teachers are lower than those of the Office of Education for each of the projection years excepting the last two (figure 4). In the final year, the DYNAMOD II projection is 3.1 percent higher than that of the Office of Education. The greatest difference is in 1964-65, when the DYNAMOD II estimate is 4.5 percent less than that of the Office of Education.

Figure 5 shows DYNAMOD II projections of secondary school teachers to be somewhat less than those of the Office of Education for each of the projection years. The percent difference increases each year to 1964-65, where the DYNAMOD II projection is 10.1 percent lower than that of Office of Education. The difference then decreases for the remaining years, becoming 2.7 percent in 1969-70.

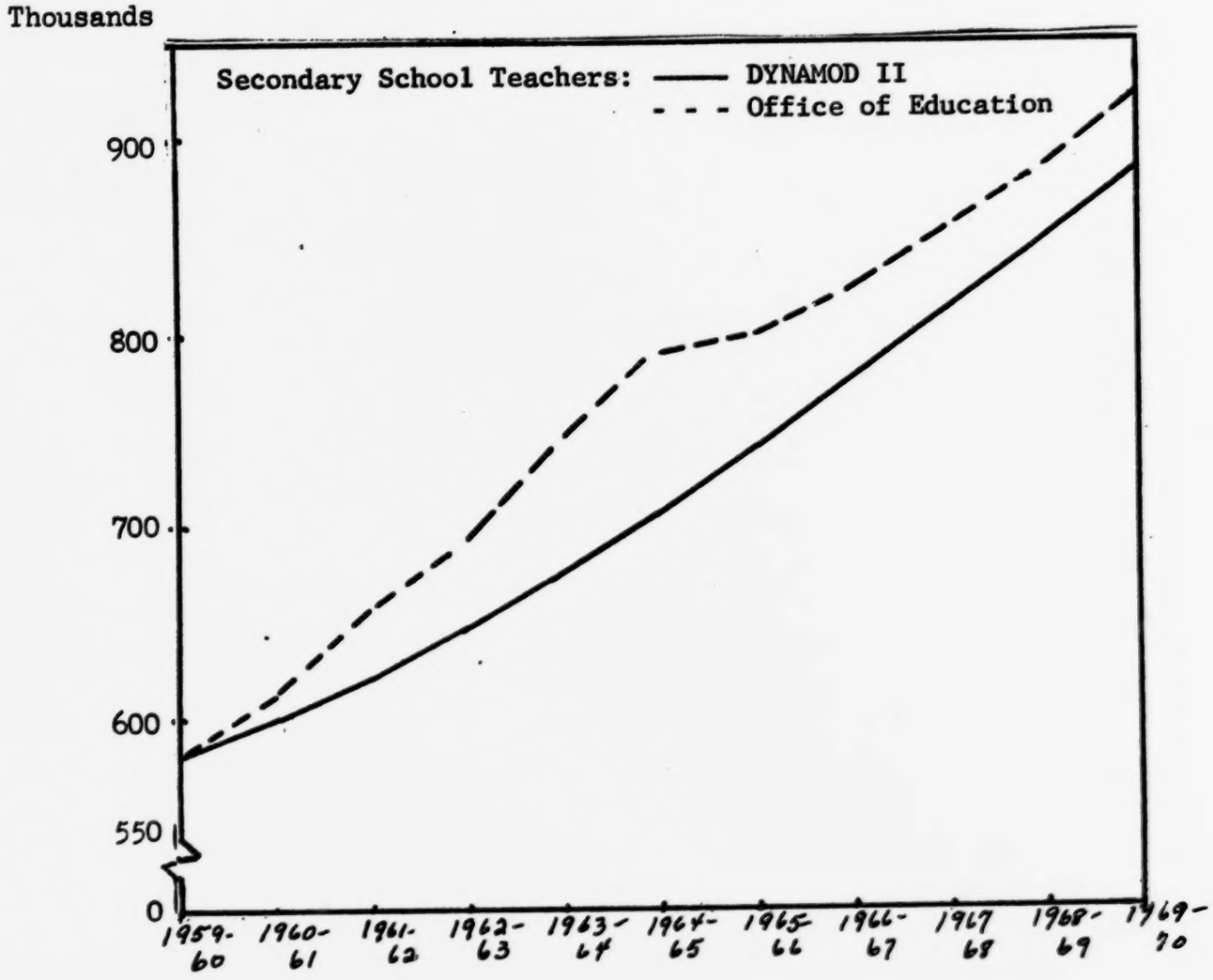
DYNAMOD II projections of college teachers are higher than those of the Office of Education through 1964-65 (figure 6). For the remaining years, DYNAMOD II figures are less than those of the Office of Education, with a difference of 3.2 percent in the final academic year, 1969-70.

Figure 4.--DYNAMOD II projections of elementary school teachers as compared with Office of Education projections, 1959-60 to 1969-70



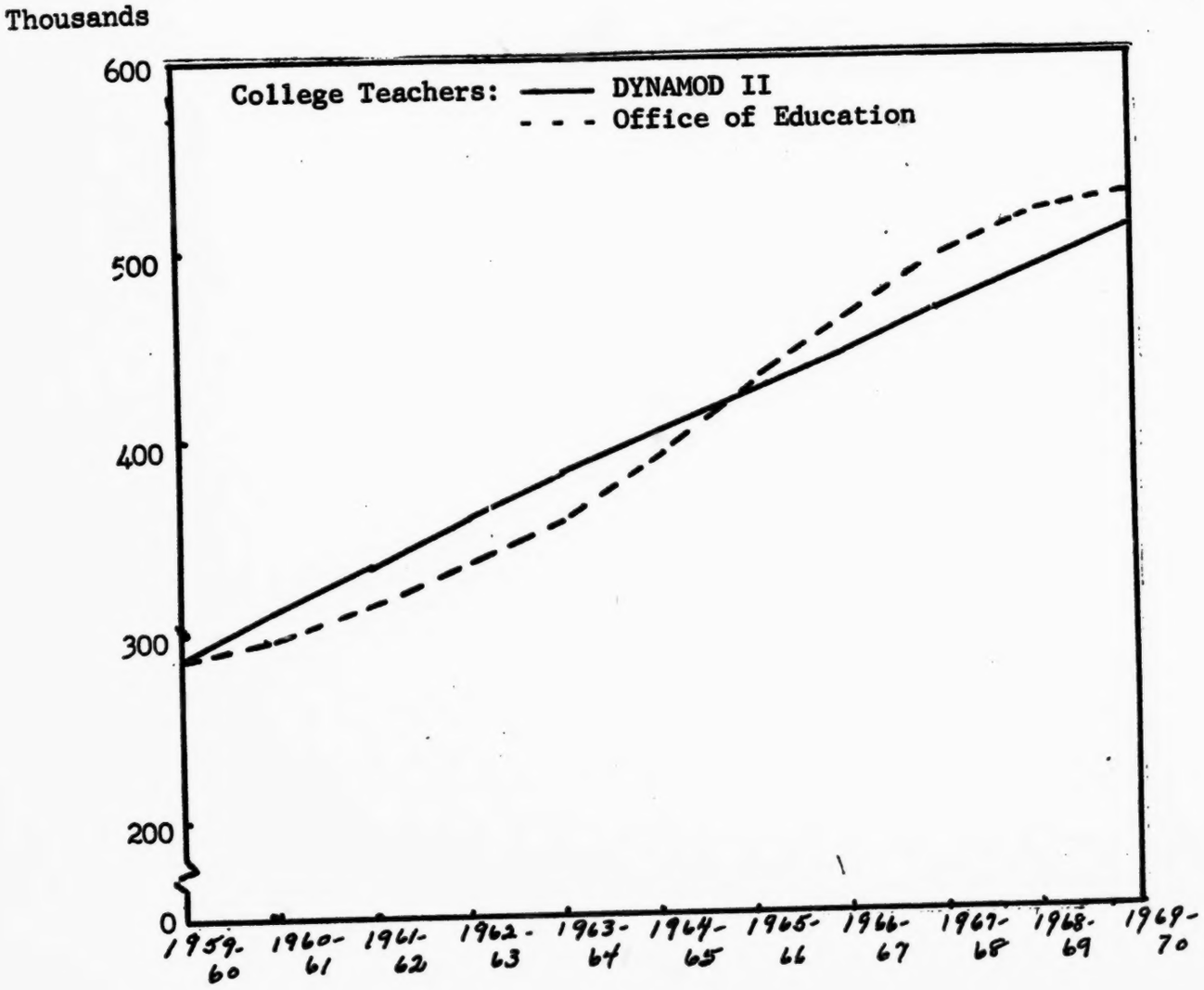
Source: Appendix table A-2

Figure 5.-DYNAMOD II projections of secondary school teachers as compared with Office of Education projections, 1959-60 to 1969-70



Source: Appendix table A-2

Figure 6.-DYNAMOD II projections of college teachers as compared with Office of Education projections, 1959-60 to 1969-70



Source: Appendix table A-2

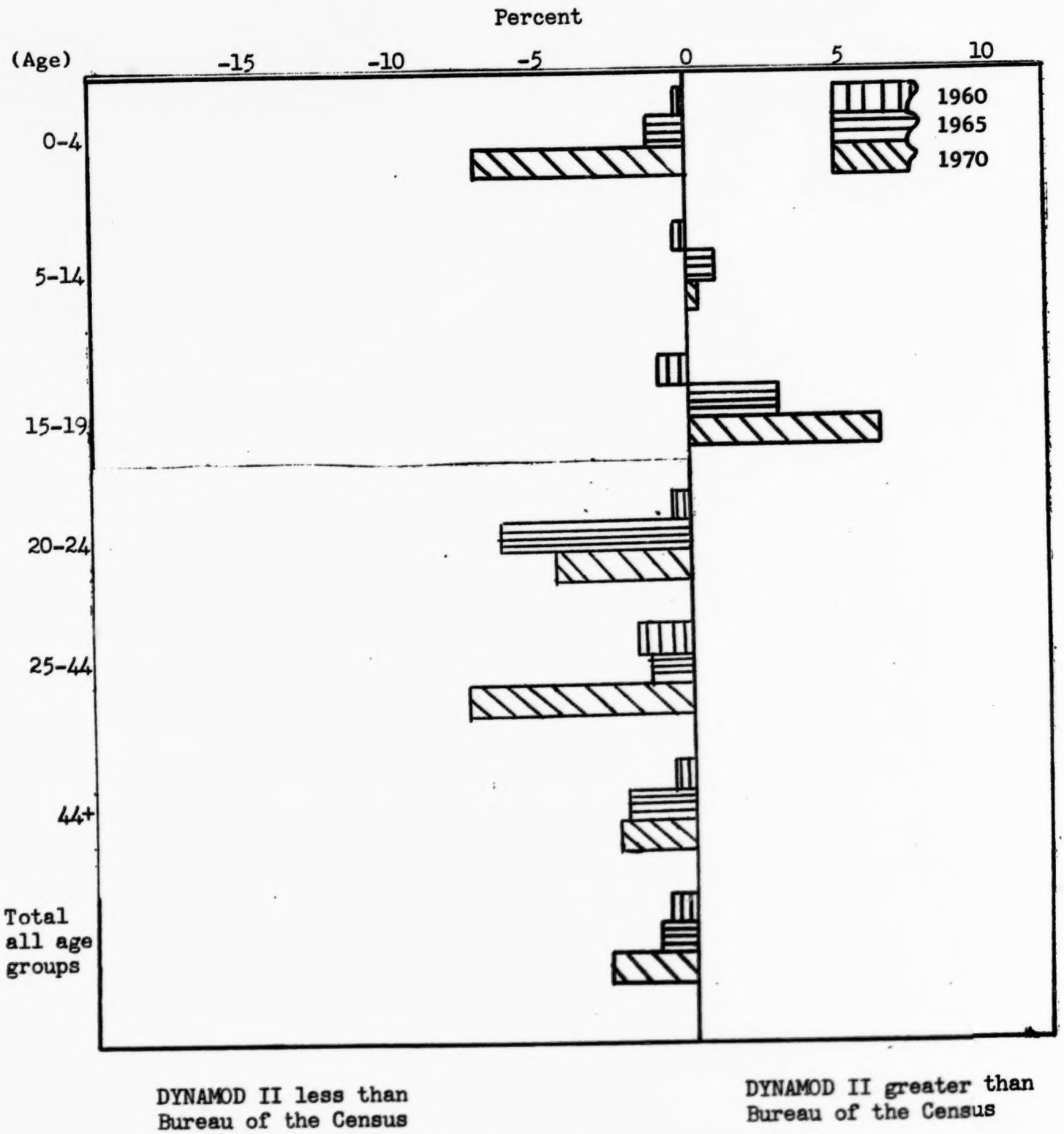
Other Demographic Characteristics

Presented below are comparisons of the results of DYNAMOD II's projections of age, sex and race to those of the Bureau of the Census. A minor data compatibility problem is encountered in comparing the Series "B," Bureau of the Census-projected population data, to those derived from the DYNAMOD II Series "B" projections. The absolute numbers of Series "B" births (Census projections) were obtained from Current Population Reports, Series P-25, No. 345 of July 29, 1966. The resulting population was then compared with the projected population in Current Population Reports, Series P-25, No. 286 of July 1964. This was due to unavoidable time restrictions and late procurement of the July 1966 data for comparative analysis.

Actually, had the 1966 data been used, the differences in the population projections would have been even smaller than those discussed below, since the Bureau of the Census' 1966 projections of the population were revised downward. Further, the Census projections are centered on July 1, while DYNAMOD II is centered on April 1. The differences, however, were not great enough to justify reworking the tables and charts which had previously been completed.

Age. The degree of agreement of the projections of the age composition of the population in DYNAMOD II with the reference projections published by the Bureau of the Census is illustrated in figure 7. With the exception of the 15-19 year old group for 1966, the relative differences between the DYNAMOD II projections and those of the Bureau of

Figure 7.-Differences between DYNAMOD II and Bureau of the Census population projections, by age, 1960-1970



Source: Appendix table A-3

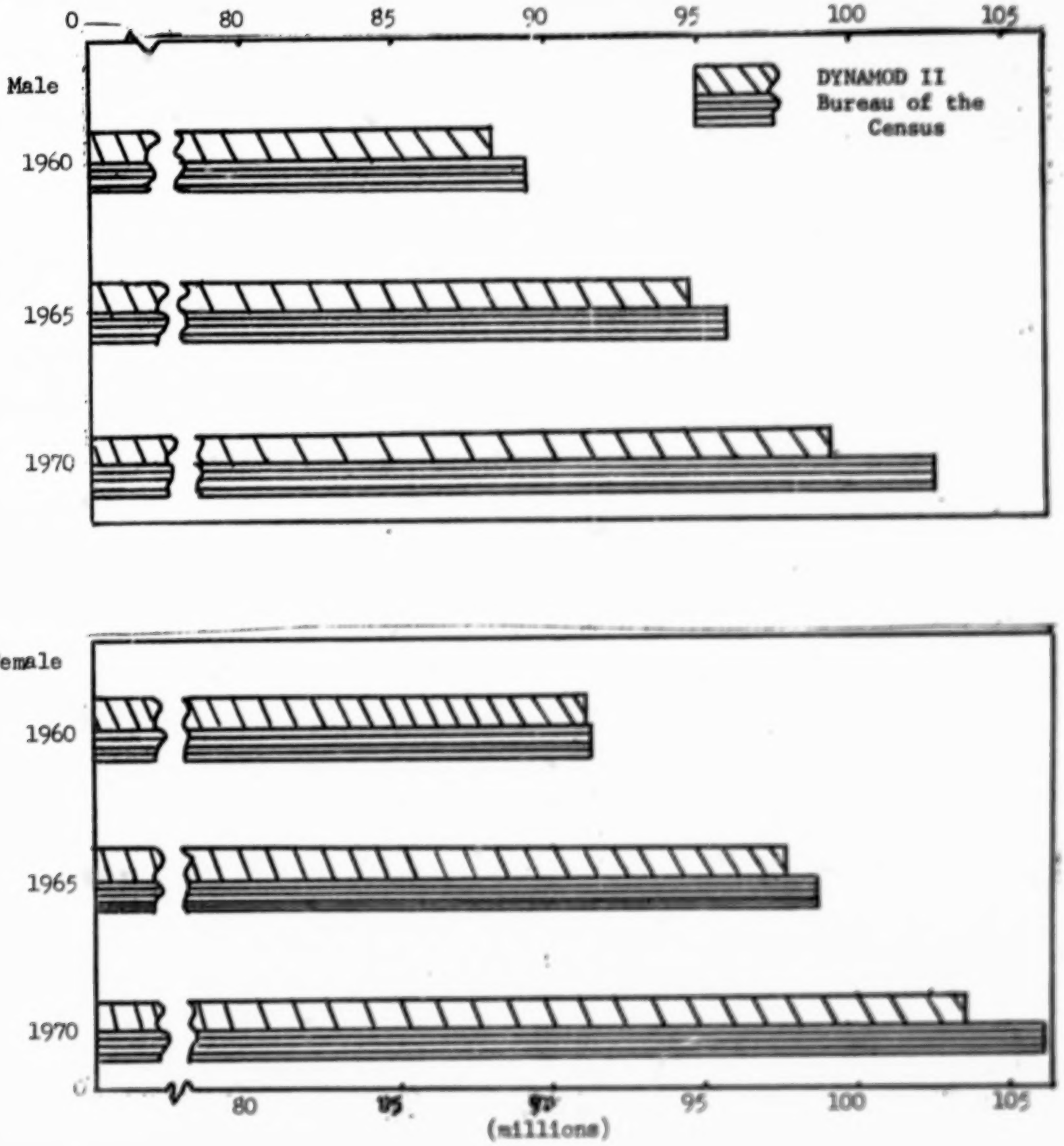
Census all were less than 7.6 percent.

As would be expected, the size of the relative errors tends to increase with the length of the projection interval. With the exception of the 5-14 year old group, DYNAMOD II projections tend to be below those of the Bureau of the Census in the final projection year.

Sex. Figure 8 shows DYNAMOD II projections by sex for the projection years 1960, 1965, and 1970. DYNAMOD II appears to be underprojecting males relative to females for both 1965 and 1970. For males, the DYNAMOD II 1970 projection is 3.3 percent less than the Bureau of the Census projection, while for females the difference is 2.5 percent. However, these differences most likely result from the initial differences present in 1960. In this year, DYNAMOD II was 1.1 percent less than the Bureau of the Census for males, and for females the difference was only .1 percent. In the method of projection used by DYNAMOD II, this initial difference is carried through and compounded for the remaining years.

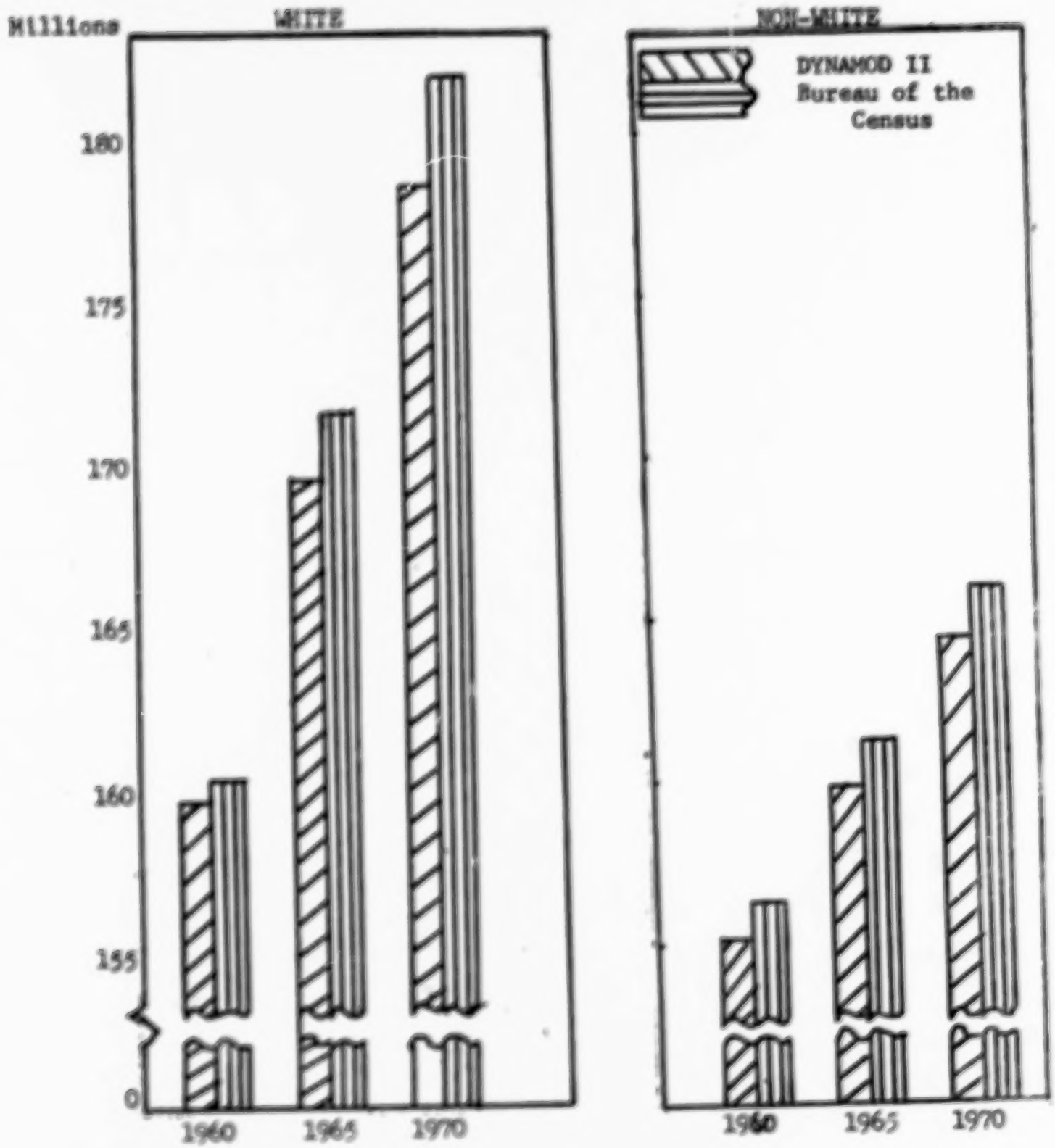
Race. A graphic comparison of DYNAMOD II and Bureau of the Census projections by race is shown in figure 9. For whites, the DYNAMOD II projection in 1960 is .3 percent below the Bureau of the Census estimates, becoming 1.8 percent below in 1970. For non-white, DYNAMOD II is initially 2.9 percent lower than Bureau of the Census, and this percent remains nearly constant throughout the projection period. The relative difference between white and non-white (.3 and 2.9 percent,

Figure 8.-DYNAMOD II projections compared with Bureau of the Census projections, by sex, 1960-1970



Source: Appendix table A-4

Figure 9.-DYNAMOD II projections compared with Bureau of the Census projections, by race, 1960-1970



Source: Appendix table A-5

respectively) in 1960 is attributable to sampling error. The Bureau of the Census projections were taken from Current Population Reports, Series P-25, No. 345, July 29, 1966.

Limitations of the Data

The data are subject to all the limitations published elsewhere by the Office of Education and, where applicable, the Bureau of the Census. The basic data inputs are derived primarily from the Bureau of the Census' 1/1,000 samples data tape, and hence are subject to sampling errors which become relatively larger as the population is subdivided in more detail. Efforts were made to adjust known differences, but these efforts cannot be considered to be completely effective.

For this initial report, the major effort was expended on obtaining suitable fits of the major educational population categories (elementary school students, secondary school students, and so on) to the reference bases. Therefore, only secondary emphasis was placed on the sex, race and age distributions within the entire population. As a result, some of the categories such as age have rather large relative errors. More emphasis will be placed on these items in future reports.

In addition to errors in the data inputs, estimates of the transition probabilities also are subject to error. Many of the estimates of the probabilities have been adjusted to make the model's population conform more closely to the reference data published elsewhere within the Office of Education. However, in doing this the errors in the estimates of the probabilities were confounded with the sampling errors of the inputs, making it impossible to develop measures of the precision of the probabilities.

One of the most frequently hypothesized limitations applicable to a model such as DYNAMOD II is that the population may not be Markovian in its behavior. This may be true. However, the point in question really is not whether a Markov process truly governs the population, but rather, whether the population's behavior is reasonably well represented by a Markov process.2/

2/ If applied researchers were to be limited only to models where the underlying processes were "proven", few models would ever be built. For example, econometricians would not build predictive models but only structural models.

SPECIAL ANALYSES

This portion of the report presents three special analyses relating to current topics in educational analysis. The first, "Birth Variations," gives an indication of how changes in the birth rate can affect the educational population over a period of time. Only one such variation is presented here, but the rates can be varied to any degree of difference desired.

The second analysis, "Variations in Retention Rates" serves a dual purpose. It shows what changes in the composition of the educational population might be expected by keeping a higher proportion of students or teachers in the system. It also indicates the effect of a one percent error in a retention rate on the estimates of the population.

The third analysis, "Student-Teacher Ratios," probes some of the possible outcomes of pursuing such mixed policies as, for example, introducing programs to keep more students in the system without introducing companion programs aimed at increasing teacher retention rates.

Birth Variations

The ultimate validity of any set of population projections is known to be highly dependent on the agreement between actual and assumed birth rates. Sudden shifts in the birth rate of the population caused by the outbreak of war, business conditions, new birth control devices, or from whatever source, can have marked effects on previous projections of the numbers of people in various categories of interest.

It is a great convenience in a population projections model to have the flexibility of easily changing the assumed birth rates.[10] For example, educational planners and analysts are free to postulate any desired impact on the birth rate of a policy emanating within or outside of the educational system, and they can then obtain an estimate of the impact on the educational population as a result of the postulated policy.

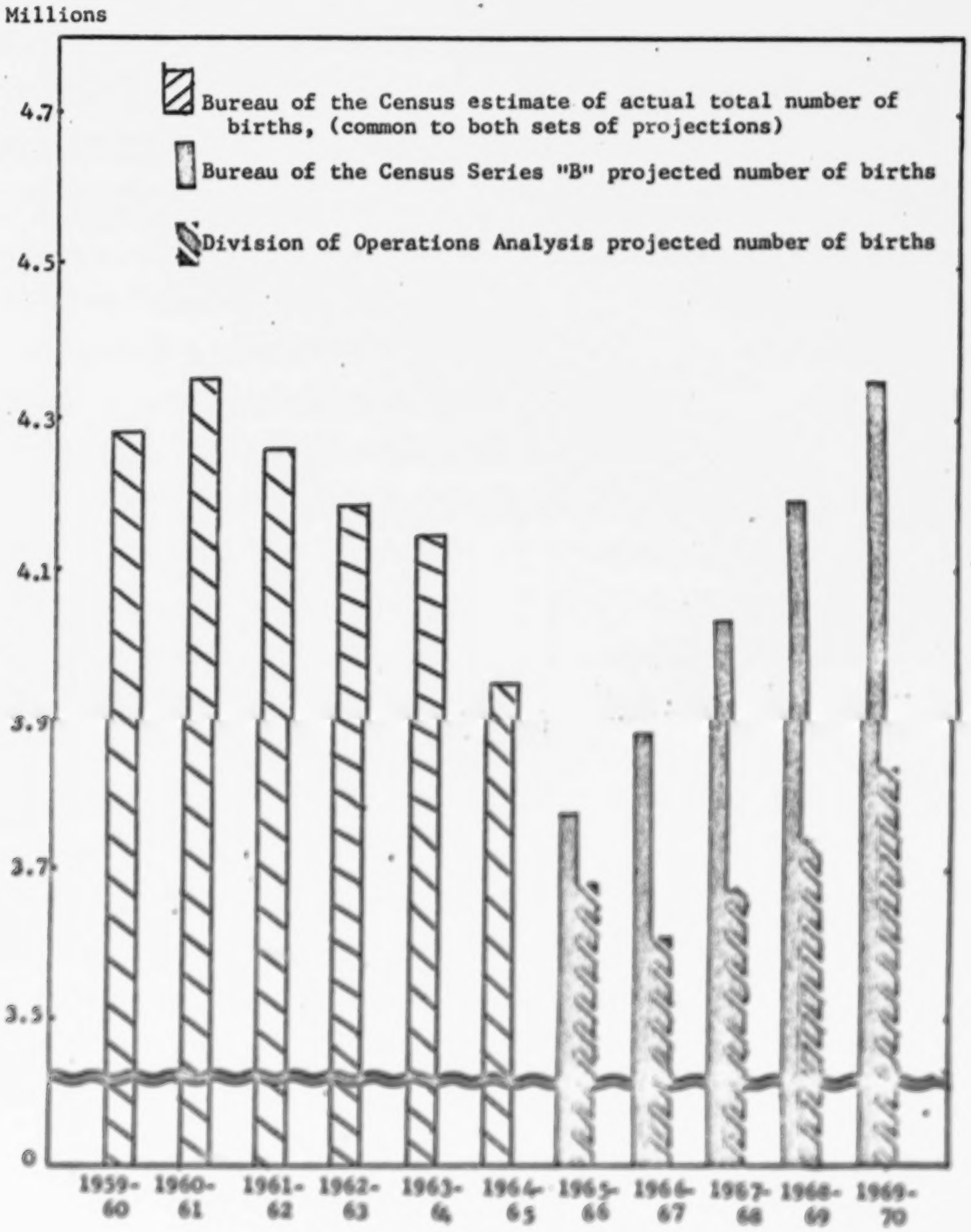
Presented below is an example of the population effects caused by using different assumptions regarding births. Note that the years 1959-60 through 1964-65 are common to both sets of projections. For those years, estimated actual birth data were available, and therefore were used. For the remaining years in the projection interval, estimates by the Bureau of the Census or the Division of Operations Analysis were used. Although in this instance, the Division of Operations Analysis made its own assumptions regarding the birth rates from 1966 to 1970, the point to keep in mind is that any set of birth rates desired could have been used as inputs to DYNAMOD II (figure 10).[11]

As may be expected, differences arise in the projected (1966-1970) population figures according to the particular type of birth figures used as inputs. Projections of population groups based on the higher Series "B" births show up consistently higher than those resulting from DYNAMOD II birth estimates. In certain age groups, differences in the projected population group totals become more pronounced with the increased number of years in the projection interval.

10/ The same may be said for death rates.

11/ For the years 1960 through 1965, number of actual births as estimated by the Bureau of the Census are used in both sets of population projections.

Figure 10.-Birth projections used in DYNAMOD II, as estimated by the Division of Operations Analysis and the Bureau of the Census, 1959-60 to 1969-70.



Source: Appendix table B-1 and Technical Note No. 11

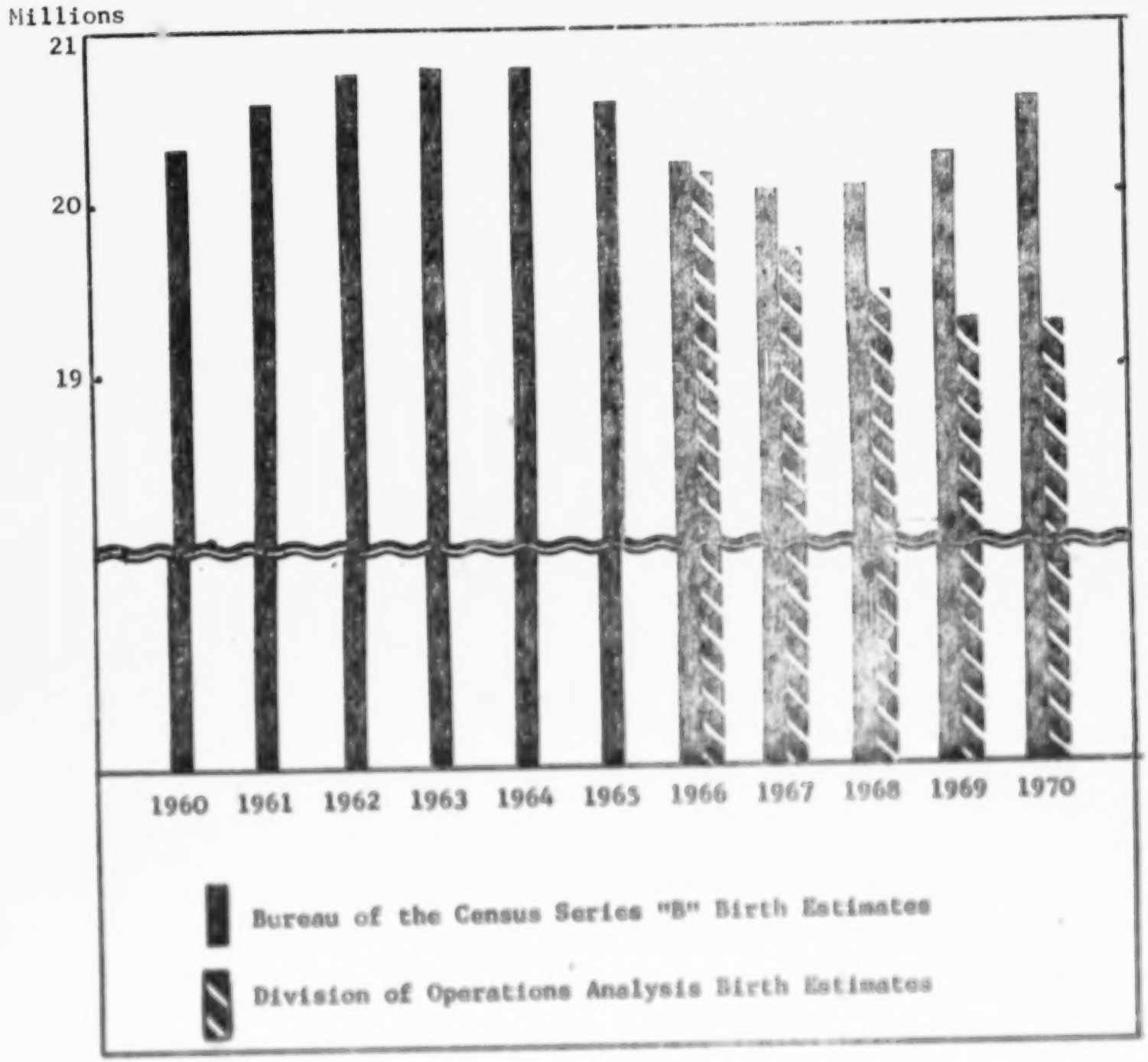
The 0-4 year old age group shows the greatest difference, amounting to 1.3 million by the year 1970 (figure 11). It may be noted that the higher birth rates from Series "B" births in the 0-4 year old group are reflected the following year in the totals for the 5-14 year olds (figure 12). This is due to an artifact in the model caused by the use of groupings, instead of using single years of age: a small proportion of increased populations of 0-4 year olds are transferred to the 5-14 year group during one cycling of the data because of the age transition probability coefficient. This artifact will be avoided by using single years of age in future network flow models. Differences due to increased Series "B" births, however, are not reflected beyond the 15-19 year group because of the short length of the projection span (figure 13).

Among the student groups, the assumed differences in birth rates affect only elementary and secondary school students, i.e., there is no effect on the number of college students introduced by the higher number of births in Series "B", because the period of projection is only five years (appendix table B-3). Obviously, however, if the population had been projected for a greater number of years, effects of birth variations would ultimately be felt in all age groups.

For the projections to 1970 by race, the births resulting from the use of Series "B" estimates show an excess of 1.4 million whites and 323,000 nonwhites over those using Division of Operations Analysis estimated births, or a difference of 0.8 percent and 1.3 percent respectively (appendix table B-4).

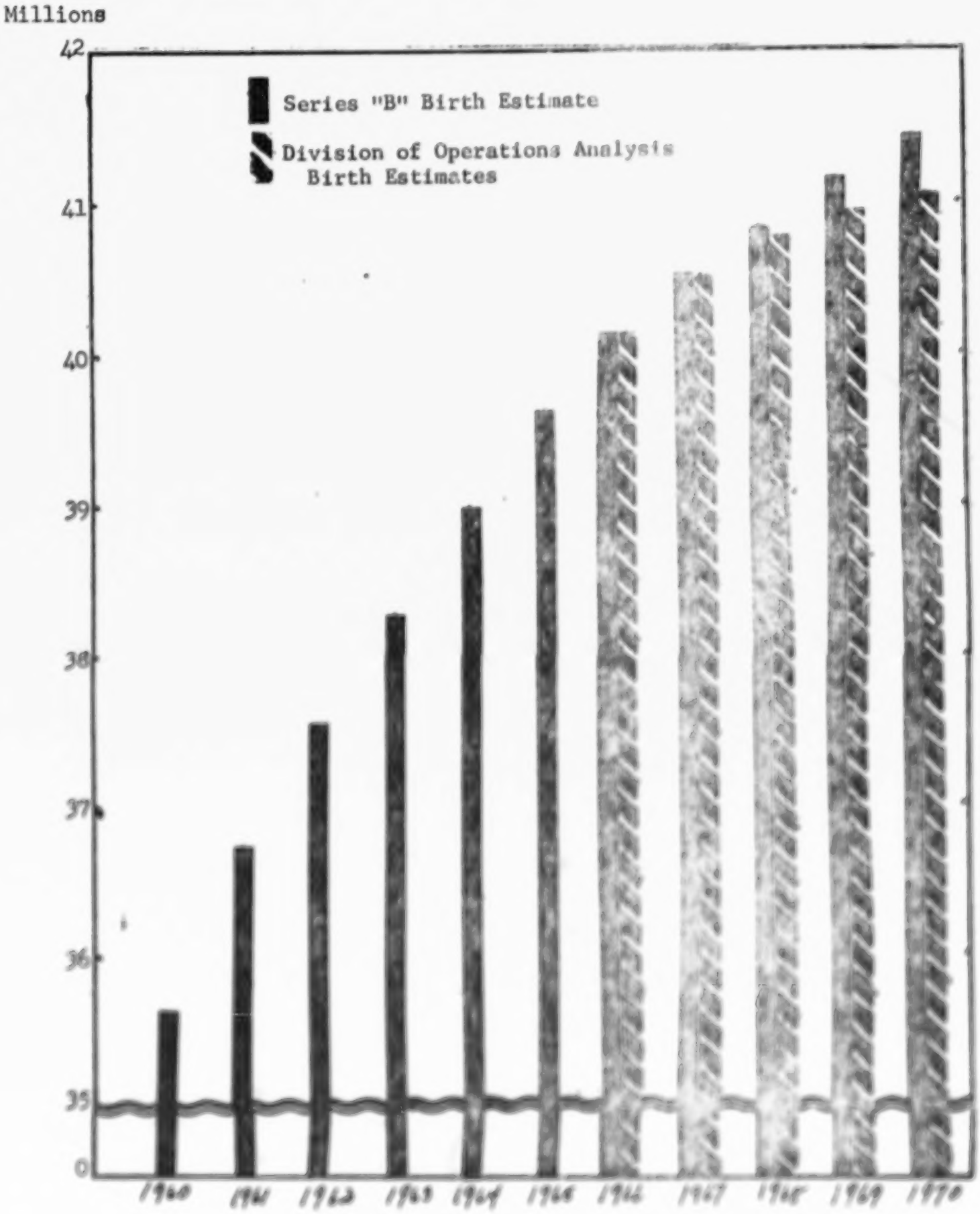
For male and female projections, differences amount to 867,000

Figure 11.-Comparison of DYNAMOD II population projections of 0-4 year olds, using different birth estimates, 1960-1970



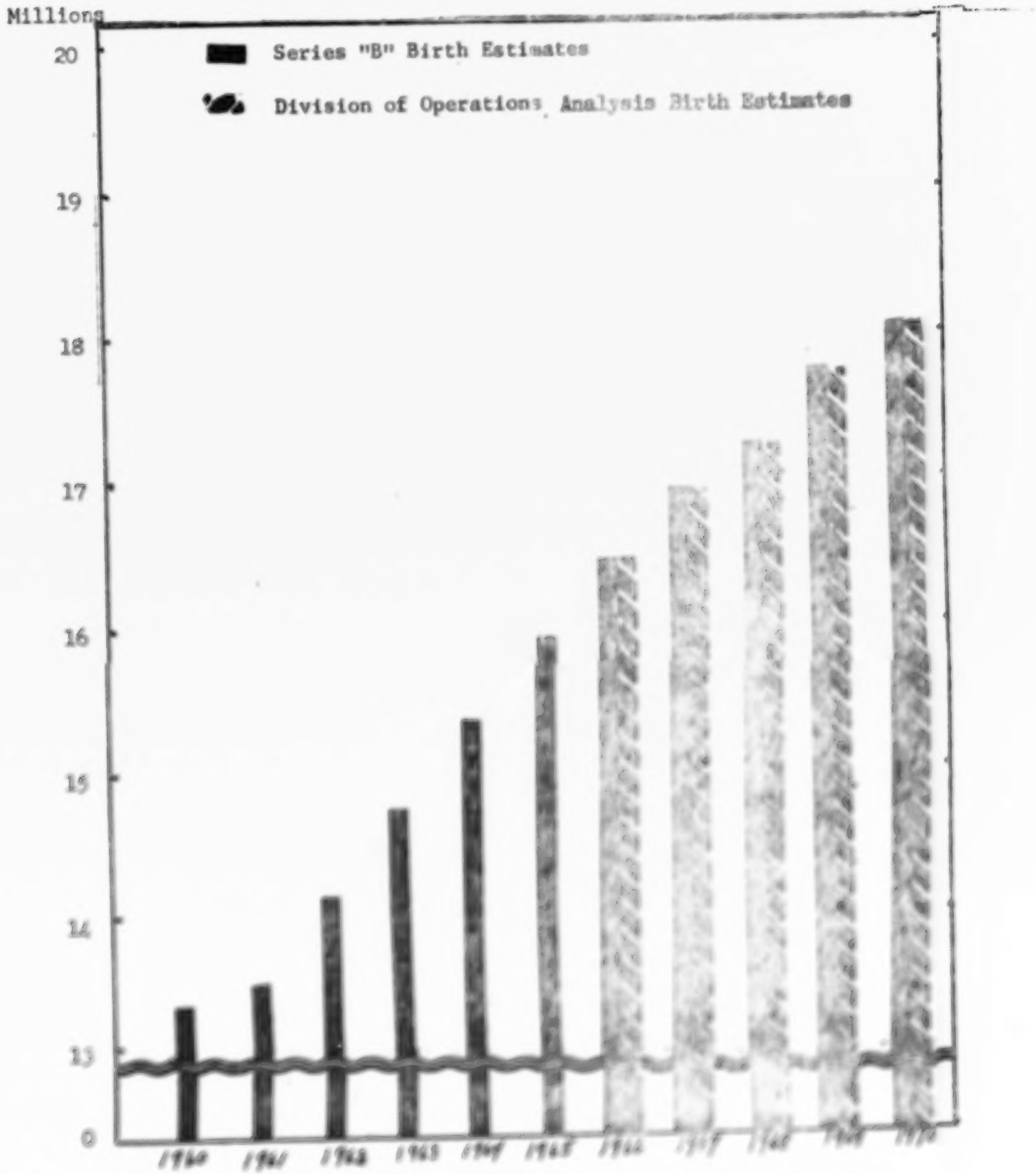
Source: Appendix tables A-3 and B-2

Figure 12.-Comparison of DYNAMOD II population projections of 5-14 year olds, using different birth estimates, 1960-1970



Source: Appendix tables A-1 and B-2

Figures 13.-Comparison of DYNAMOD II projections of 15-19 year olds using different birth estimates, 1960-1970



Source: Appendix tables A-1 and A-2

males (0.9 percent) and 830,000 females (0.8 percent) by the year 1970, (appendix table B-5).

Variations in Retention Rates

Varying the retention rates for students and teachers consisted of increasing by one percent the probability that a student or teacher would remain in his respective educational category from one year to the next. Thus, if a retention rate (transition probability) was .8000 in the original DYNAMOD II projection, it was changed to .8080, or by one percent. Now, because the row values in the transition matrix had to add to 1.0000, the increment (.0080) had to be taken from among the remaining row entries. It was decided to take the balance from the "other" category, since by so doing, the remaining structure of the educational system would not be directly affected.[12] Basically, then, the effect of an increase in a retention rate is to keep more individuals in a given category without altering the relative flows within the educational system.

The increases in the rates were made one at a time, to avoid confounding the effects of the changes.[13]

Students. The effect of increasing the elementary school student retention rate by one percent was to raise the level of the projection

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12/ Some secondary effects obviously would, and should, show up later through the minor impact on the transfers from the "other" category to the receiver categories, as well as through an increase in the number of secondary school and college students, and so on, later affected by the change in the flows. The secondary effects will be examined in a future report.

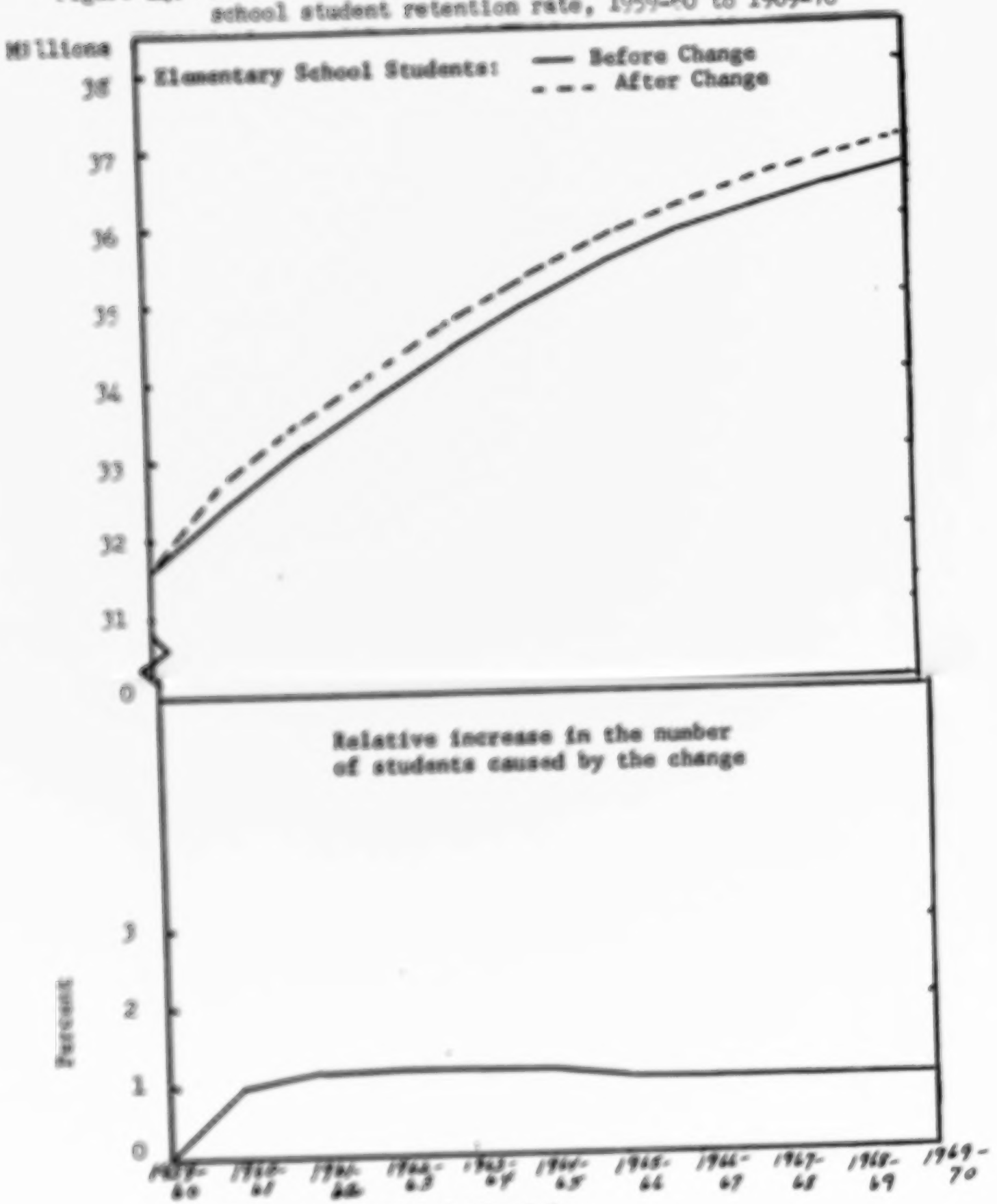
13/ A special computer run is planned for the future in which the effects of a simultaneous one percent change in all educational retention rates, students and teachers alike, will be examined.

for the 1969-70 school year from about 36.7 million to slightly over 37.0 million, or by one percent (figure 14). The relative impact of increasing the elementary school student retention rate, that is, the percent increase in students over the base line projection, was lowest for elementary school students, remaining at about one percent over the entire projection interval. Furthermore, the "time to maximum response," i.e., the time required to reach the maximum relative difference over the base line projection was shortest for this group, reaching the maximum level (1.1 percent) within two years.

Knowledge of the relative impact of changes in the educational population can be of great aid to educational planners, analysts and decisionmakers by providing them with information regarding required changes in the capacity of the system resulting from the implementation of policies that change the numbers of students or teachers in the system. For example, if planners estimate their capacity requirements on the basis of a given set of flow rates for students and teachers, they will be interested in learning what additional changes in capacity may be required by policies that affect the retention rates of students. In the case of elementary school students, for example, an increase of one percent in the retention rate would require capacity in the system sufficient to handle the original projections plus about one percent more each year in the interval.[14/]

[14/] Another set of secondary effects which transpire when the retention rate is varied for, say, elementary school students, is a change in the number of secondary and college students. These will be discussed in a future report.

Figure 14.- Results of a one percent increase in the elementary school student retention rate, 1959-60 to 1969-70



Source: Appendix table C-1

However, for secondary school students, the requirements are somewhat higher. A one percent increase in their retention rate would raise the DYNAMOD II projection for 1969-70 from about 13.4 million to nearly 13.8 million students, or 2.4 percent (figure 15). That is, for each 1.0 percent increase in the retention rate, an enrollment increase equal to the original projection plus an additional 2.4 percent could be expected within 10 years.[15] Not all the relative impact would be expected immediately, as the graph of the relative increases indicates. By the 1964-65 school year, for example, the increased requirements are about 1.9 percent higher than for the original projections.

As might be expected, there are limits to the relative impacts of policy changes. From the projection structure of DYNAMOD II, it appears that the maximum relative impact on the number of secondary school students is about 2.5 percent, reached in about 12 years from the implementation point.[16]

The greatest relative impact of all three student categories is achieved with college students (figure 16), where the figure becomes 3.0 percent by 1969-70, with an apparent maximum of 3.3 percent in

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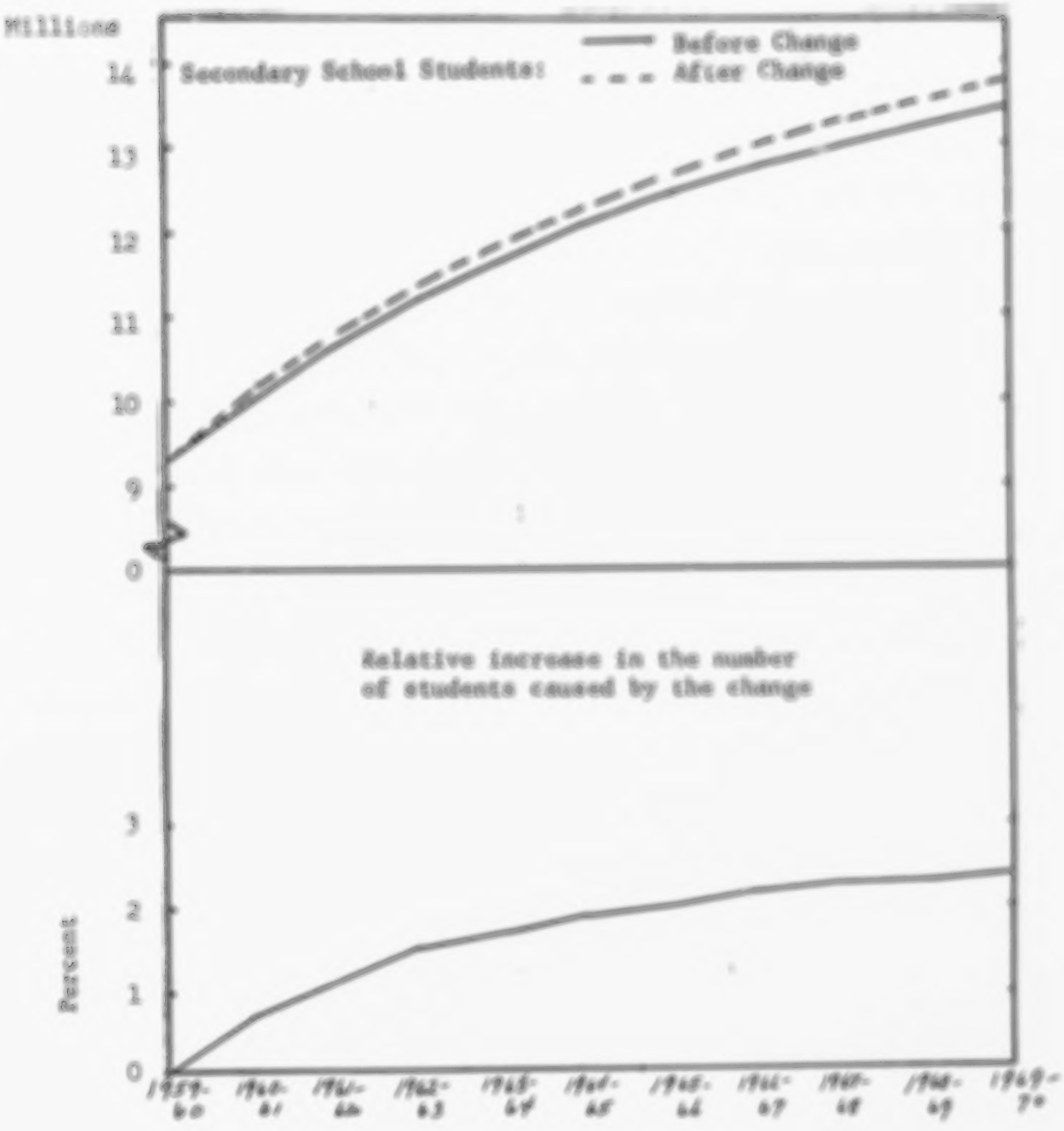
15/ There are obvious limits to such a statement. First, if the required capacity were not available, then there simply would not be room for that many students. Second, the changes discussed here are marginal (small) changes, and may not be applicable over large ranges of possibilities. For example, a change of 10 percent in the retention rate may not require places for an additional 24 percent enrollment in 10 years.

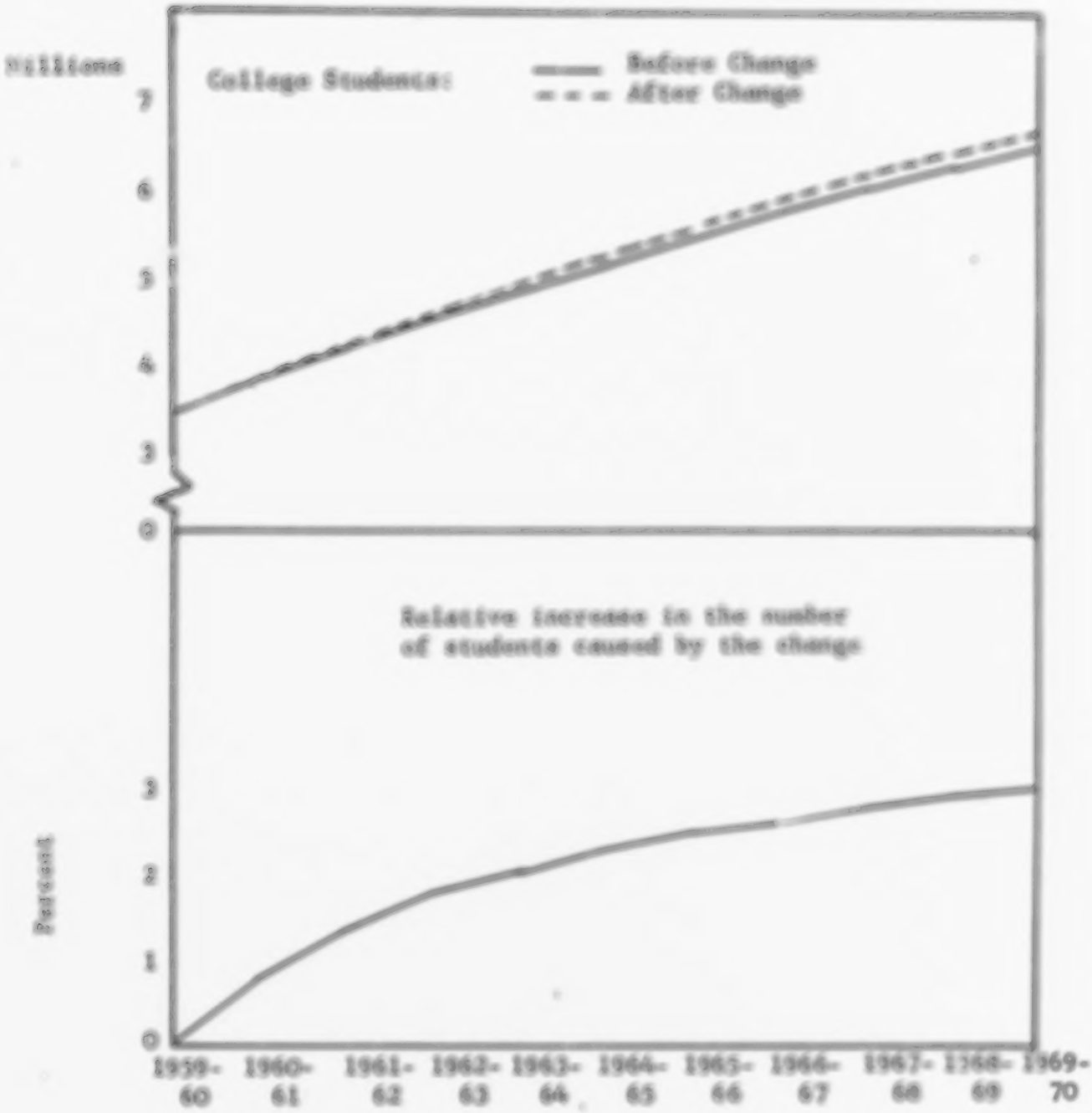
16/ The 12-year figure is an estimate taken from the chart, and is not the result of a statistical fit of the data.

Figure 15.-Results of a one percent increase in the secondary school student retention rate, 1959-60 to 1969-70



Source: Appendix table C-1

Figure 16.--Results of a one percent increase in the college student retention rate, 1959-60 to 1969-70



Source: Appendix table C-1

about 15 years. While this group has the largest relative response to retention policies, the absolute effect by the end of the 10-year projection interval is smallest, being only 190 thousand students above the original 1969-70 DYNAMOD II projection of 6.5 million students.

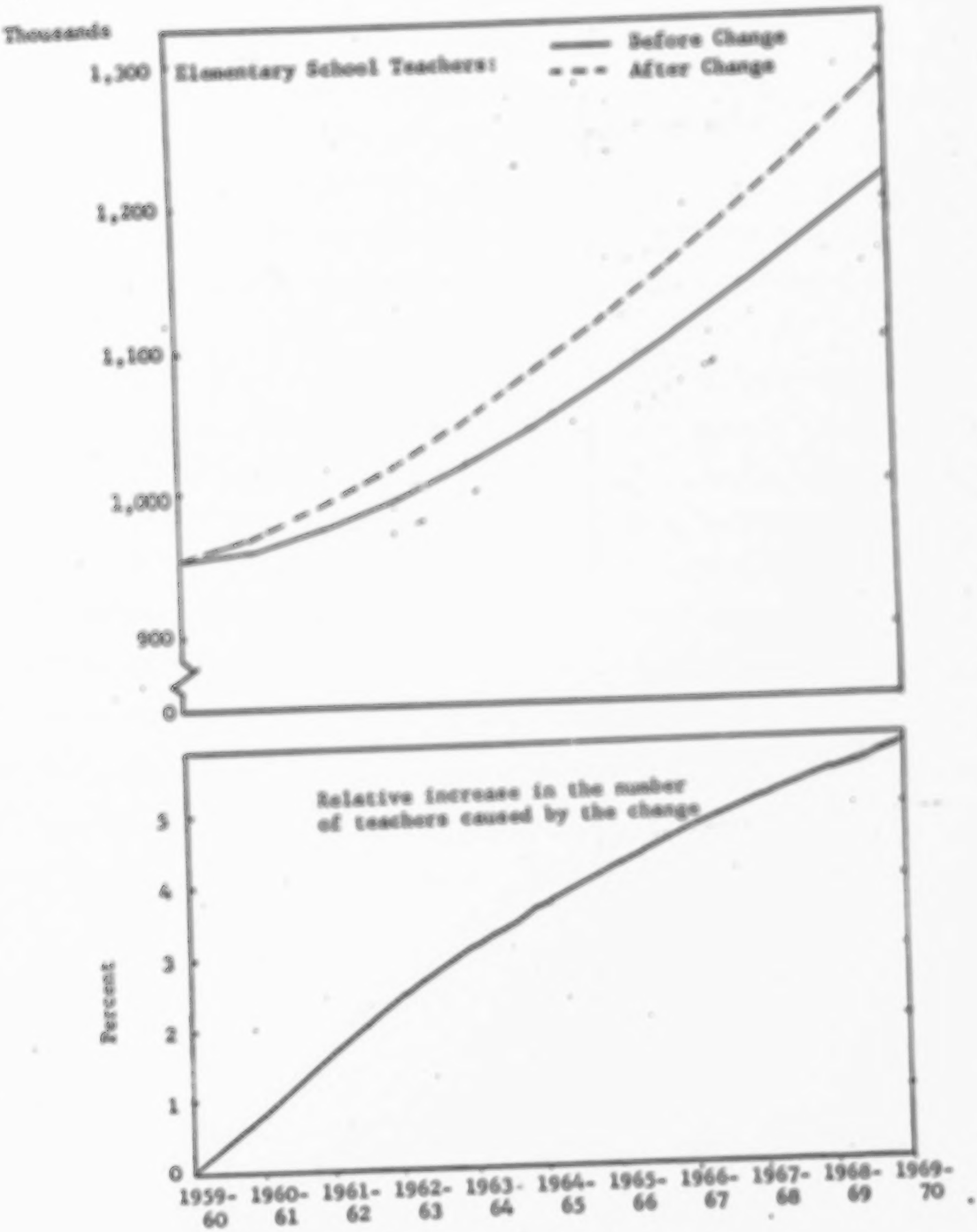
Teachers. The teaching sector appears to be much more sensitive to increases in the retention rates than is the student sector, although, of course, the absolute numbers of persons involved are much smaller than is the case for students. The effects of increasing the retention rates for teachers are shown in figures 17, 18, and 19. The relative response factors are quite high by the end of the 10-year interval, being 4.8 percent for secondary school teachers, and close to 6 percent for elementary school and college teachers, respectively.[17]

Effective policies aimed at increasing the holding power for teachers in the system, then, would appear to be particularly desirable means of increasing the total population of teachers. This seems to be especially true for college teachers, where a heavy dependence on returns from the "other" category was required to obtain an acceptable fit to the reference projections.[18]

17/ The impact on the student-teacher ratios are discussed below.

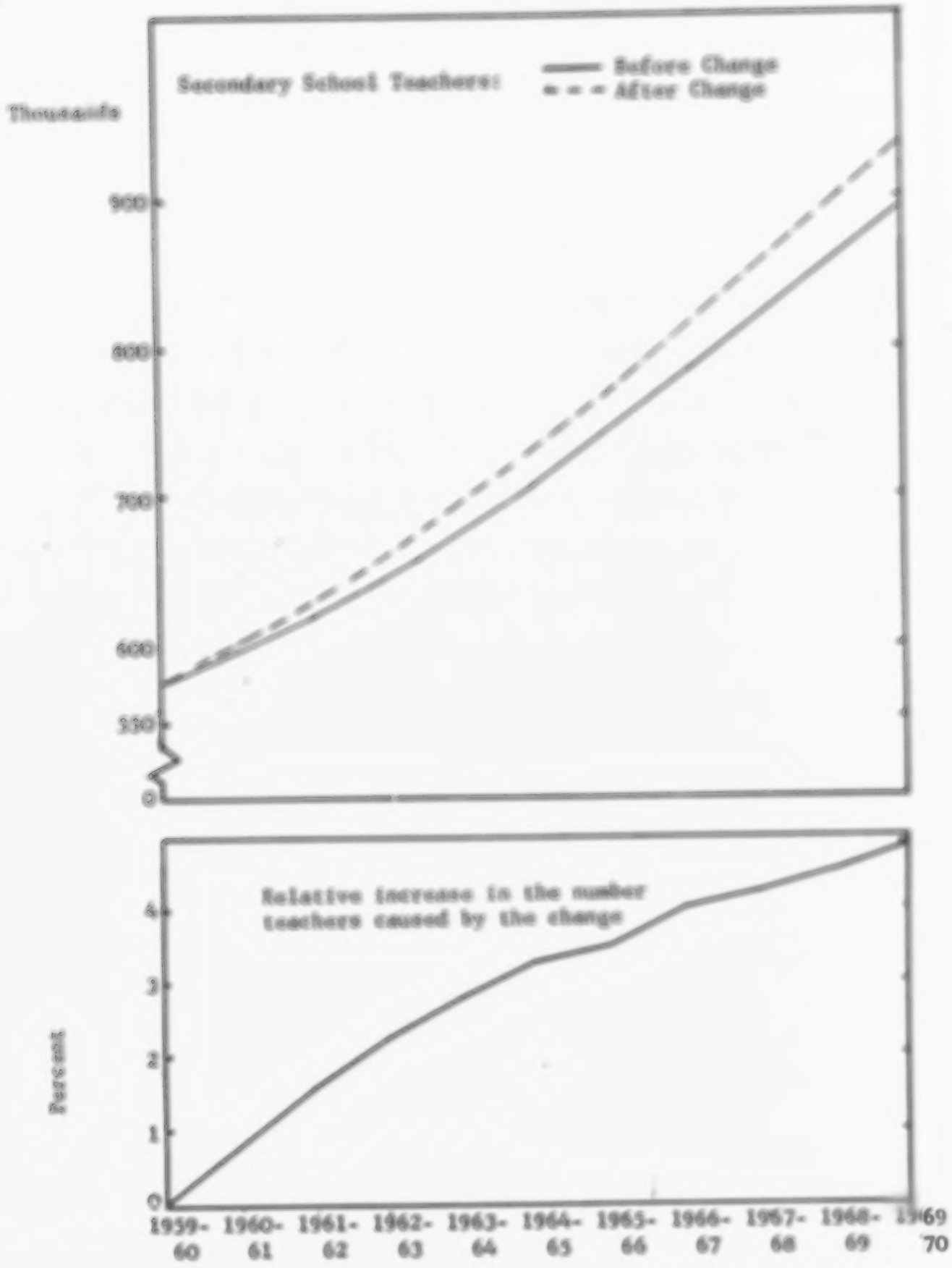
18/ If this heavy transfer had not been specified, a satisfactory fit to the standard projections could not have been obtained under any circumstances. A special computer run was made where the teacher retention rate was set as high as possible and the transfers from "other" back to the profession were eliminated. The DYNAMOD II projections for 1969-70 were 361 thousand college teachers, or considerably below the standard OE projection of 524 thousand teachers. If the DYNAMOD II structure is approximately correct, the implication is that projections made on the basis of assumed student-teacher ratios may not be realized because the system may not produce the required numbers of teachers and the numbers returning to the profession from "other" may not be sufficient to fill the gap.

Figure 17.-Results of a one percent increase in the elementary school teachers' retention rate, 1959-60 to 1969-70



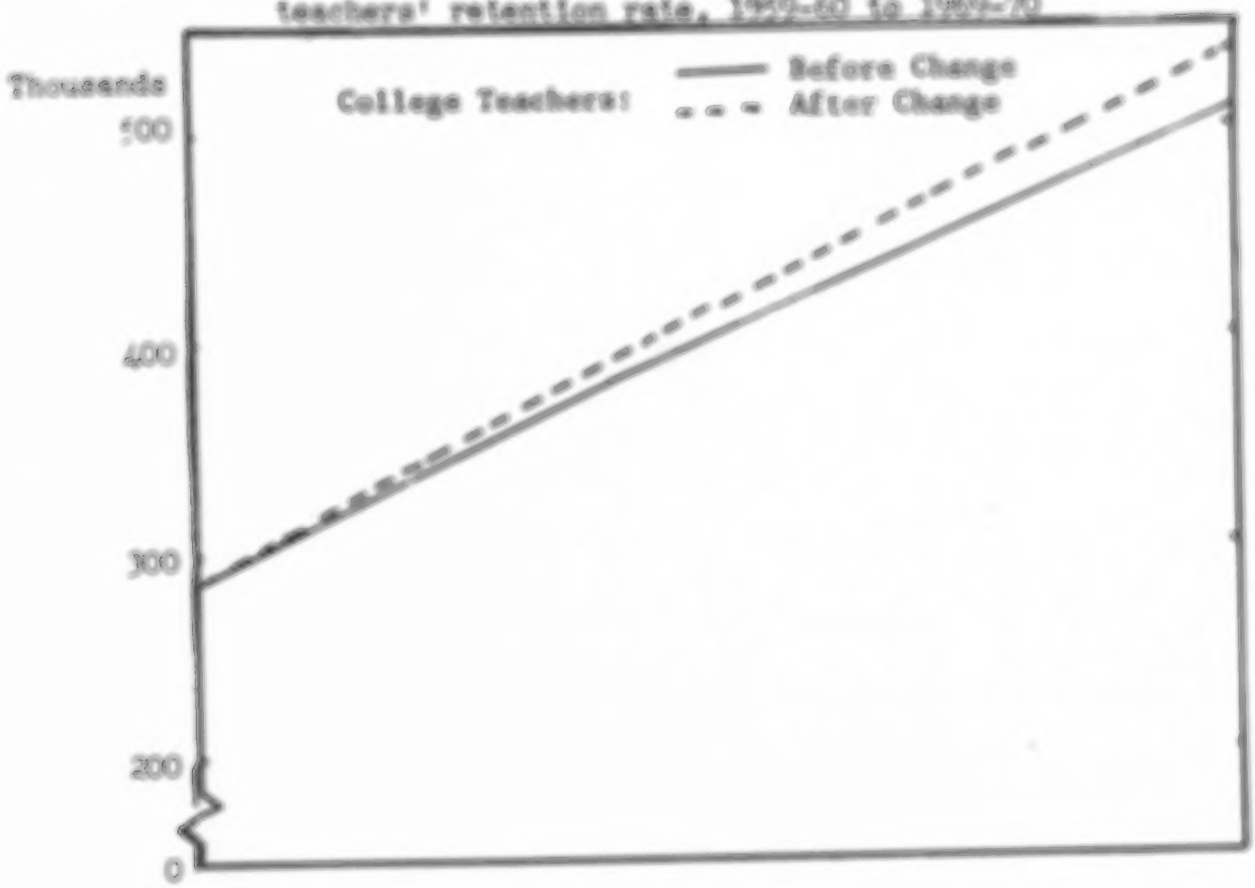
Source: Appendix table C-2

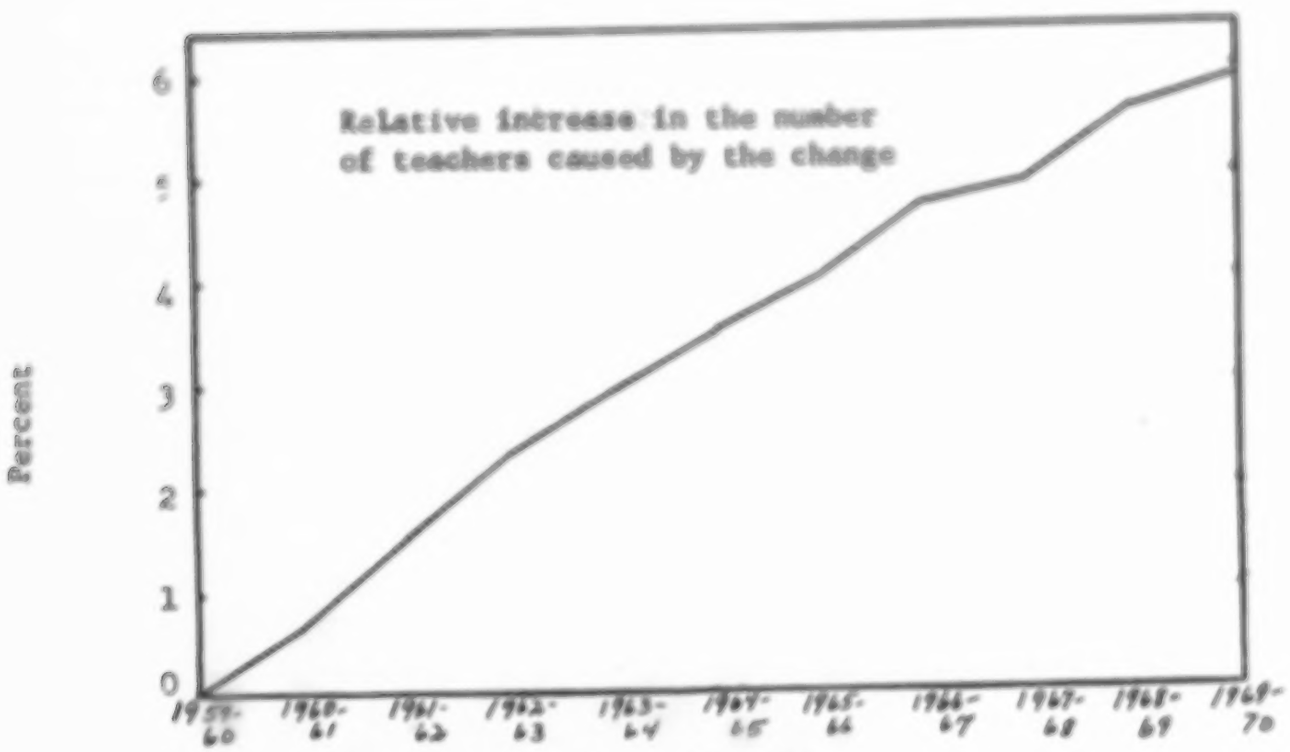
Figure 14.-Results of a one percent increase in the secondary school teachers' retention rate, 1959-60 to 1969-70



Source: Appendix table C-2

Figure 19.--Results of a one percent increase in the college teachers' retention rate, 1959-60 to 1969-70





Source: Appendix table C-2

Student-Teacher Ratios [12]

One of the frequently-used measures of the "load" on parts of the educational system is the student-teacher ratio. Although the accepted range of variation of this ratio is a frequent and unresolved matter of discussion, the fact that it is frequently discussed and published in educational literature suggests that, despite its limitations, it is a tool of planning and policymaking.

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[12] Those student-teacher ratios discussed below that are hypothesized to result from a one percent increase in the retention rates of students or teachers contain a minor degree of noncomparability with the OE base data from which they are calculated. The reason for this is that: (a) an elementary school student in DYNAMOD II is defined as being in grades K through 8, while in OE publications the definition includes only those not attending a junior or senior high school; and (b) DYNAMOD II elementary and secondary school teachers follow the OE definitions exactly. The number of grades 7 and 8 students enrolled in high school organization units (and therefore classified by OE as secondary school students) are about equal to the equivalent of the total 8th grade enrollment in public schools (see OE 10030-66, tables 2 and 3 and OE 10024-65, table 3 plus about 15 percent for nonpublic school enrollments). Thus, about 9-10 percent of the elementary school students affected by a change in the retention rate in DYNAMOD II would fall in the secondary school classification of OE. The main effect, therefore, would be concentrated in the third decimal digit of the retention rate and hence would have only a minor impact on the relative response patterns for the students.

Because of this, and also because the teacher classification in DYNAMOD II follows the OE definitions, it was decided to apply the percent response patterns to one percent changes in the respective student and teacher retention rates from DYNAMOD II to the published OE student-teacher ratios for elementary and secondary schools. The student-teacher ratios shown as "Office of Education base data" in appendix table D-1 are combined from the separately-published ratios for public and nonpublic schools as shown in OE 10030-66, table 23, using the number of classroom teachers in table 22 as combinatorial weights. The student-teacher ratios for the college sector were computed directly from the DYNAMOD II output.

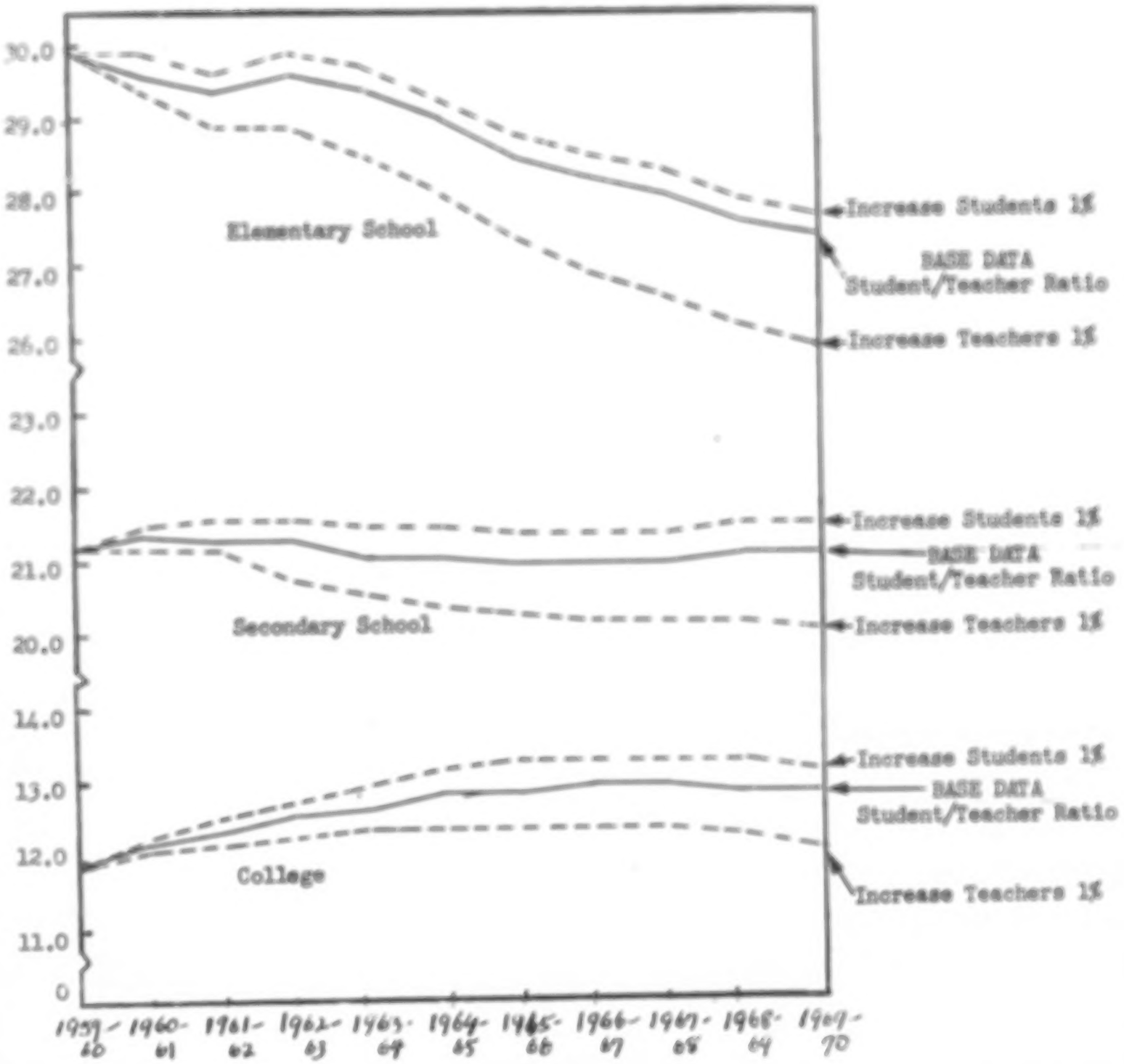
This being the case, one consideration of the impact of policy changes on retention rates within the system should be the effect of those changes on the student-teacher ratios in the respective levels of the educational process.

For example, it might seem intuitively desirable to increase the retention rates of all students, for isn't a better-educated population more productive, and doesn't well-being increase with productivity? Perhaps. But if an increase in the number of students processed within the system comes about at the expense of unacceptably high student-teacher ratios, the quality of the education received by the students, hence their productivity, may in fact be less than would have been the case had the policy not been implemented.

Consider another planning problem. Suppose policymakers are in agreement that (1) a particular student-teacher ratio is too high, and (2) the proper policy to follow to lower it is to increase the retention rate of teachers in the system. How much should the rate be changed to meet predetermined objectives?

DYNAMOD II can be of use in cases such as those described above. To illustrate the model's utility, student-teacher ratios are presented in this section in a manner that reflects a range of outcomes of policy alternatives. The student-teacher ratios calculated from base line data are contrasted with the ratios resulting from increases in the student retention rates with the teacher rates unchanged, as well as with the converse, i.e., the student retention rates unchanged with the teacher retention rates increased. All increases in the retention rates were one percent.

Figure 20.-Comparison of the variations in the student-teacher ratio caused by selected increases in student or teacher retention rates, by level of schooling, 1959-60 to 1969-70



Source: Appendix table D-1

The results of these calculations are shown in figure 20. As can be inferred from the chart, two important patterns are present. First, the policy of increasing the retention rates of students without changing the retention rates of teachers has its greatest impact on the college student-teacher ratio and least affects the elementary school student-teacher ratio. Second, a one percent increase in the retention rates of teachers has a very strong effect on the ratios, lowering all three from between 4.7 to 6.2 percent by the 1969-70 academic year, as highlighted in the discussion table below:

An increase of one percent in the retention rate of:	Produces a percent difference in the base line student-teacher ratio approximately equal to: 1964-1965	1969-1970
Elementary school students	1.0	1.1
Secondary school students	1.9	1.9
College students	2.3	2.3
Elementary school teachers	-3.4	-5.5
Secondary school teachers	-3.3	-4.7
College teachers	-3.9	-6.2

The data in appendix table D-1 indicate that, for the college sector, either alternative of increasing the student retention rate or the teacher retention rate will be associated with an absolute increase in the student-teacher ratio over the middle range of the projection interval. This suggests that if the desired policy is to ultimately increase the number of students in the system over the base line projections, one way of minimizing the impact on the student-teacher ratio is to sequence the operations: to first pursue policies that will retain more teachers in the system, and then take the desired action to increase the retention rates of students.

Examining the data in more detail it can be noted that, even though more students enter the system each year at the elementary school level, the projected number of elementary school teachers increases at a faster rate than the students, lowering the student-teacher ratio from 29.9 in 1959-60 to 27.4 in 1969-70. In the secondary school sector, little change is noted over the interval.

The college student-teacher ratio increases over the interval because the projected number of students is increasing proportionately faster than the number of teachers. From 1959-60 to 1969-70 the college student-teacher ratio changes from 11.9 to 12.9.

If a one percent increase is made in the retention rates of secondary school students the relative difference in the student-teacher ratio over the base line ratios is slightly greater than for the elementary school sector. A one percent increase in the retention rate for college students increases the student-teacher ratio from a base line value of 12.7 to 13.2 in the 1969-70 academic year.

For teachers, an increase of one percent in the retention rate of those in elementary schools, holding the students' rate constant, decreases the student-teacher ratio from 27.4 to about 25.9 during the interval 1960-70.

The same type of change to the retention rate of secondary school teachers reduces the secondary school student-teacher ratio from 21.1 to 20.1 for the same period (a decrease of about 4.7 percent), while for college teachers, the one percent change reduces the student-teacher ratio from 12.9 to 12.1 or a decrease of 6.2 percent.

One point not discussed in this report that will be covered in a future report is the "spillover" of students to higher levels of schooling or into teaching and their subsequent impact on the student-teacher ratios of the affected sectors. If, for example, the retention rate of elementary school students is increased, the graduates who go on to secondary school will affect the secondary school student-teacher ratio. The spillover effect may or may not be important, depending on the amount of the increase in the retention rate and the flow structure of the affected parts of the system.

APPENDIX A

Tables of DYNAMOD II Projections Compared with Reference Projections

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Appendix Table A-1.-DYNAMOD II projections of students, 1959-60 to 1969-70
(In thousands)

		1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Elementary School Students	DYNAMOD II	31,510	32,385	33,060	33,720	34,344	34,917	35,416	35,818	36,139	36,416	36,683
	Office of Education	31,511	32,198	32,869	33,737	34,504	35,325	35,700	36,300	36,600	36,800	37,000
	Percent difference	0.0	.6	.6	-.1	-.5	-1.2	-.8	-1.3	-1.3	-1.0	-.9
Secondary School Students	DYNAMOD II	9,271	9,983	10,606	11,138	11,601	12,010	12,371	12,691	12,971	13,211	13,418
	Office of Education	9,271	9,983	10,595	11,312	12,183	12,791	12,800	13,100	13,600	14,100	14,600
	Percent difference	0.0	0.0	.1	-1.5	-4.8	-6.1	-3.4	-3.1	-4.6	-6.4	-8.1
College Students	DYNAMOD II	3,377	3,755	4,112	4,465	4,810	5,142	5,457	5,753	6,028	6,282	6,514
	Office of Education	3,377	3,583	3,861	4,175	4,495	4,950	5,435	5,924	6,410	6,820	6,966
	Percent difference	0.0	4.8	6.5	6.9	7.0	3.9	.4	-2.9	-6.0	-7.9	-6.5

Appendix Table A-2-DYNAMOD II projections of teachers, 1959-60 to 1969-70
(In thousands)

		1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Elementary school teachers	DYNAMOD II	952	960	973	992	1,016	1,043	1,073	1,106	1,140	1,177	1,216
	Office of Education	952	984	1,002	1,026	1,053	1,092	1,114	1,141	1,155	1,170	1,179
	Percent difference	0.0	-2.4	-2.9	-3.3	-3.5	-4.5	-3.7	-3.1	-1.2	.6	3.1
Secondary school teachers	DYNAMOD II	580	599	622	648	677	709	744	780	817	855	893
	Office of Education	580	610	655	690	743	789	796	820	853	884	918
	Percent difference	0.0	-1.8	-5.0	-6.1	-8.9	-10.1	-6.5	-4.9	-4.2	-3.3	-2.7
College teachers	DYNAMOD II	283	308	331	355	378	400	422	443	465	486	507
	Office of Education	283	296	313	336	358	389	425	459	493	517	524
	Percent difference	0.0	4.1	6.4	5.7	5.6	2.8	-.7	-3.5	-5.7	-6.0	-3.2

Appendix Table A-3.-DYNAMOD II population projections compared to Bureau of the Census projections, by age, 1960-1970
(In thousands)

AGE		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
0-4	DYNAMOD II	20,311	20,586	20,733	20,776	20,766	20,563	20,208	20,045	20,070	20,249	20,556
	Census Bureau	20,364	20,660	20,746	20,722	20,731	20,783	20,746	20,891	21,199	21,555	22,013
	Percent difference	-.3	-.4	-.1	.3	.2	-1.1	-2.7	-4.2	-5.6	-6.4	-7.1
5-14	DYNAMOD II	35,642	36,749	37,570	38,312	38,993	39,609	40,128	40,527	40,851	41,142	41,437
	Census Bureau	35,735	36,995	37,384	38,012	38,649	39,308	40,021	40,539	40,822	41,084	41,290
	Percent difference	-.3	-.7	.5	.8	.9	.7	.3	-.02	.1	.1	.3
15-19	DYNAMOD II	13,398	13,567	14,112	14,731	15,342	15,920	16,453	16,937	17,370	17,750	18,082
	Census Bureau	13,465	13,840	14,965	15,536	16,274	16,977	17,797	17,746	18,055	18,438	18,941
	Percent difference	-.5	-2.0	-5.7	-5.2	-5.7	-6.2	-7.6	-4.6	-3.8	-3.7	-4.5
20-24	DYNAMOD II	10,932	11,611	12,114	12,556	12,991	13,443	13,913	14,396	14,884	15,368	15,840
	Census Bureau	11,112	11,404	11,875	12,600	13,119	13,623	13,987	15,104	15,671	16,405	17,104
	Percent difference	-1.6	1.8	2.0	-.3	-1.0	-1.3	-.5	-4.7	-5.0	-6.3	-7.4
25-44	DYNAMOD II	46,879	46,430	46,131	45,942	45,849	45,844	45,927	46,095	46,346	46,677	47,082
	Census Bureau	47,132	47,064	46,991	46,960	46,910	46,836	46,843	47,021	47,513	47,846	48,216
	Percent difference	-.5	-1.3	-1.8	-2.2	-2.3	-2.1	-2.0	-2.0	-2.5	-2.4	-2.4
44 +	DYNAMOD II	52,406	53,309	54,162	54,975	55,756	56,508	57,238	57,951	58,650	59,342	60,029
	Census Bureau	52,866	53,780	54,629	55,450	56,283	57,145	58,020	58,911	59,792	60,636	61,430
	Percent difference	-.9	-.9	-.9	-.9	-.9	-1.1	-1.3	-1.6	-1.9	-2.1	-2.3

Appendix table A-3 Cont'd.

Appendix table A-3 (Cont'd.)

AGE		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total	DYNAMOD II	179,568	182,252	184,822	187,292	189,697	191,887	193,867	195,951	198,171	200,528	203,026
	Census Bureau 1/	180,676	183,742	186,591	189,278	191,967	194,671	197,414	200,212	203,052	205,964	208,994
	Percent difference	-.6	-.8	-.9	-1.0	-1.2	-1.4	-1.8	-2.1	-2.4	-2.6	-2.9

Note: DYNAMOD II figures as of April 1; Census Bureau as of July 1.

1/ Columns may not add to total due to rounding.

Appendix table A-4.-DYNAMOD II population projections compared with those of the Bureau of the Census, by sex, 1960-1970
(In thousands)

		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Male	DYNAMOD II	88,337	89,611	90,828	91,994	93,128	94,154	95,077	96,051	97,100	98,219	99,412
	Census Bureau	89,328	90,777	92,117	93,369	94,636	95,914	97,214	98,545	99,900	101,296	102,756
	Percent difference	-1.1	-1.3	-1.4	-1.5	-1.6	-1.8	-2.2	-2.5	-2.8	-3.0	-3.3
Female	DYNAMOD II	91,231	92,642	93,995	95,300	96,567	97,731	98,789	99,900	101,072	102,309	103,616
	Census Bureau	91,347	92,965	94,473	95,909	97,330	98,757	100,199	101,666	103,150	104,668	106,240
	Percent difference	-.1	-.3	-.5	-.6	-.8	-1.0	-1.4	-1.7	-2.0	-2.3	-2.5

Appendix table A-5.-DYNAMOD II population projections compared with those of the Bureau of the Census, by race, 1960-1970
(In thousands)

		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
White	DYNAMOD II	159,508	161,702	163,790	165,786	167,710	169,453	171,027	172,685	174,452	176,334	178,331
	Census Bureau 1/	160,033	162,586	164,982	167,248	169,449	171,442	173,292	175,219	177,249	179,386	181,629
	Percent difference	-.3	-.5	-.7	-.9	-1.0	-1.2	-1.3	-1.4	-1.6	-1.7	-1.8
Non-White	DYNAMOD II	20,060	20,551	21,033	21,508	21,98[illegible]	22,432	22,839	23,266	23,720	24,194	24,697
	Census Bureau	20,651	21,170	21,675	22,169	22,670	23,141	23,568	24,014	24,484	24,978	25,498
	Percent difference	-2.9	-2.9	-3.0	-3.0	-3.0	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1

1/ U.S. Department of Commerce, Bureau of the Census, Current Population Report, Series P-25, No. 345

APPENDIX B

Tables of the Effects of Using Different Birth Estimates

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Appendix Table B-1.-DYNAMOD II birth projections as estimated by the Division of Operations Analysis and the Bureau of the Census, 1965-66 to 1969-70
(In thousands)

Year [1]	Division of Operations Analysis [2]	Bureau of the Census Series "B" [3]	Difference (Series "B" minus Division of Operations Analysis)
1965-66	3678	3758	80
1966-67	3590	3880	290
1967-68	3670	4034	364
1968-69	3740	4191	451
1969-70	3830	4353	523

1/ Births are centered on fiscal year beginning July 1. The births used in DYNAMOD II from 1959-60 to 1964-65 were published in "Births and Death Rate Projections Used in Present Student-Teachers Population Flow Models", T. Okada, Technical Note Number 11, November 1966.

2/ Ibid.

3/ U.S. Bureau of the Census, Current Population Reports, Population Estimates, Series P-25, No. 345, Op. Cit.

Appendix table B-2.-Comparison of DYNAMOD II population projections using different birth estimates, by selected age groups, 1966-1970
(In thousands)

AGE		1966	1967	1968	1969	1970
0-4	Series "B"	20,208	20,045	20,070	20,249	20,556
	DOA Birth estimates	20,128	19,691	19,420	19,275	19,250
	Percent difference	-0.4	-1.8	-3.3	-5.1	-6.8
5-14	Series "B"	40,128	40,527	40,851	41,142	41,437
	DOA Birth estimates	40,128	40,513	40,770	40,942	41,062
	Percent difference	0.0	0.0	-0.2	-0.5	-0.9
15-19	Series "B"	16,453	16,937	17,370	17,750	18,082
	DOA Birth estimates	16,453	16,937	17,370	17,746	18,064
	Percent difference	0.0	0.0	0.0	0.0	-0.1

1/ Series "B" estimates from U.S. Bureau of Census Current Population Reports, Population Estimates, Series P-25, No. 345, Op. Cit.

2/ Division of Operations Analysis estimates, T. Okada, Births and Death Rate Projections Used in Present Student-Teacher Population Flow Models, Technical Note Number 11, November, 1966.

Appendix Table B-3.-Comparison of DYNAMOD II population projections using different birth estimates, by student population, 1965-66 to 1969-70
(In thousands)

		1965-66	1966-67	1967-68	1968-69	1969-70
Elementary school students	Series "B"	35,416	35,818	36,139	36,416	36,683
	DOA Birth estimates	35,416	35,810	36,091	36,281	36,414
	Percent difference	0.0	0.0	-0.1	-0.4	-0.7
Secondary school students	Series "B"	12,371	12,691	12,971	13,211	13,418
	DOA Birth estimates	12,371	12,691	12,970	13,206	13,405
	Percent difference	0.0	0.0	0.0	0.0	-0.1
College students	Series "B"	5,457	5,753	6,028	6,282	6,514
	DOA Birth estimates	5,457	5,753	6,028	6,282	6,514
	Percent difference	0.0	0.0	0.0	0.0	0.0

Appendix Table B-4.-Comparison of DYNAMOD II population projections using different birth estimates, by white and nonwhite, 1966-1970
(In thousands)

		1966	1967	1968	1969	1970
White	Series "B"	171,027	172,685	174,452	176,334	178,331
	DOA Birth estimates	170,962	172,385	173,861	175,380	176,958
	Percent difference	0.0	-0.2	-0.3	-0.5	-0.8
Non-White	Series "B"	22,839	23,266	23,720	24,194	24,697
	DOA Birth estimates	22,825	23,194	23,527	23,969	24,374
	Percent difference	-0.1	-0.3	-0.8	-0.9	-1.3

Appendix Table B-5.-Comparison of DYNAMOD II population projections using different birth estimates, by male and female, 1966-1970
(In thousands)

		1966	1967	1968	1969	1970
Male	Series "B"	95,077	96,051	97,100	98,219	99,412
	DOA Birth estimates	95,040	95,860	96,723	97,617	98,545
	Percent difference	0.0	-0.2	-0.4	-0.6	-0.9
Female	Series "B"	98,789	99,900	101,072	102,309	103,616
	DOA Birth estimates	98,750	99,717	100,714	101,732	102,785
	Percent difference	0.0	-0.2	-0.4	-0.6	-0.8

Appendix Table B-6.-Death rates used in DYNAMOD II

Age Interval	Category	White		Non-White	
		Male	Female	Male	Female
0-4 [1]	Elem. sch. students	.0055	.0042	.0107	.0086
	Other	.0055	.0042	.0107	.0086
5-14 [1]	Elem. sch. students	.0005	.0003	.0007	.0005
	Second. sch. students	.0005	.0003	.0007	.0005
	Other	.0005	.0003	.0007	.0005
15-19	Elem. sch. students [1]	.0013	.0005	.0016	.0008
	Second. sch. students [1]	.0013	.0005	.0016	.0008
	College students [2]	.0011	.0004	.0014	.0007
	Other [1]	.0013	.0005	.0016	.0008
20-24	Elem. sch. students [1]	.0017	.0006	.0028	.0013
	Second. sch. students [1]	.0017	.0006	.0028	.0013
	College students [2]	.0011	.0004	.0014	.0007
	Elem. sch. teachers [2]	.0011	.0004	.0014	.0007
	Second. sch. teachers [2]	.0011	.0004	.0014	.0007
	Other [1]	.0017	.0006	.0028	.0013
25-44	Elem. sch. students [1]	.0026	.0014	.0061	.0039
	Second. sch. students [1]	.0026	.0014	.0061	.0039
	College students [2]	.0017	.0006	.0028	.0013
	Elem. sch. teachers [2]	.0017	.0006	.0028	.0013
	Second. sch. teachers [2]	.0017	.0006	.0028	.0013
	College teachers [2]	.0017	.0006	.0028	.0013
	Other [1]	.0026	.0014	.0061	.0039

Table B-6 (Cont'd)

Table B-6 (Cont'd)

Age Interval	Category	White Male	White Female	Non-White Male	Non-White Female
45 & over	Elem. sch. teachers 2/	.01	.007	.016	.014
	Second. sch. teachers 2/	.01	.007	.016	.014
	College teachers 2/	.01	.007	.016	.014
	Other 1/	.0318	.0222	.0352	.0262

1/ Death Rates based on actual count of deaths for the population, U.S. Department of Health, Education, and Welfare, Vital Statistics of U.S., Vol. II, Mortality, Part A (Table 1-25), 1964, Washington, D. C.

2/ U.S. Department of Health, Education, and Welfare, "Mortality by Occupation and Industry" Vital Statistics Special Reports, Vol. 53, No. 2, September 1962 (Female rates estimated)

APPENDIX C

Tables of the Effects of Variations in the Retention Rates of Students and Teachers

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Appendix Table C-1.-Results of a 1-percent increase in the DYNAMOD II student retention rates, 1959-60 to 1969-70
(In thousands)

		1959-1960	1960-1961	1961-1962	1962-1963	1963-1964	1964-1965	1965-1966	1966-1967	1967-1968	1968-1969	1969-1970
Elementary School Students	DYNAMOD II (before change)	31,510	32,185	33,060	33,720	34,344	34,917	35,416	35,818	36,139	36,416	36,683
	DYNAMOD II (after change)	31,510	32,672	33,417	34,091	34,718	35,289	35,786	36,185	36,501	36,773	37,035
	Percent Difference	0.0	.9	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
Secondary School Students	DYNAMOD II (before change)	9,271	9,983	10,606	11,138	11,601	12,010	12,371	12,691	12,971	13,211	13,418
	DYNAMOD II (after change)	9,271	10,048	10,725	11,300	11,799	12,239	12,624	12,966	13,265	13,521	13,740
	Percent Difference	0.0	.7	1.1	1.5	1.7	1.9	2.0	2.2	2.3	2.3	2.4
College Students	DYNAMOD II (before change)	3,377	3,755	4,112	4,465	4,810	5,142	5,457	5,753	6,028	6,282	6,514
	DYNAMOD II (after change)	3,377	3,783	4,167	4,543	4,909	5,261	5,592	5,903	6,194	6,462	6,706
	Percent Difference	0.0	.8	1.3	1.8	2.0	2.3	2.5	2.6	2.8	2.9	3.0

Appendix Table C-3.-Results of a 1-percent increase in the DYNAMOD II teacher retention rates, 1960-1970
(In thousands)

		1959-1960	1960-1961	1961-1962	1962-1963	1963-1964	1964-1965	1965-1966	1966-1967	1967-1968	1968-1969	1969-1970
Elementary School Teachers	DYNAMOD II (before change)	952	960	973	992	1,016	1,043	1,073	1,106	1,140	1,177	1,216
	DYNAMOD II (after change)	952	968	990	1,014	1,047	1,082	1,118	1,157	1,198	1,242	1,286
	Percent difference	0.0	.8	1.7	2.4	3.1	3.7	4.2	4.7	5.1	5.5	5.8
Secondary School Teachers	DYNAMOD II (before change)	580	599	622	648	677	709	744	780	817	855	893
	DYNAMOD II (after change)	580	604	632	662	696	732	770	811	851	893	935
	Percent difference	0.0	.8	1.6	2.2	2.8	3.3	3.5	4.0	4.2	4.5	4.8
College Teachers	DYNAMOD II (before change)	283	308	333	355	378	400	422	443	465	486	507
	DYNAMOD II (after change)	283	310	338	363	389	414	439	464	488	513	537
	Percent difference	0.0	.6	1.5	2.3	2.9	3.5	4.0	4.7	4.9	5.6	5.9

APPENDIX D

Table of the Effects of Variations in the Retention Rates of Students and Teachers on the Student-Teacher Ratios

Appendix Table D-1.-Comparison of the variations in the student-teacher ratio caused by selected increases in student or teacher retention rates, by level of schooling, 1959-60 to 1969-70 1/

Change in retention rates	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Students: One percent increase	29.9	29.9	29.7	29.9	29.7	29.3	28.8	28.5	28.3	27.9	27.7
Off. of Ed. base data	29.9	29.6	29.4	29.6	29.4	29.0	28.5	28.2	28.0	27.6	27.4
Teachers: One percent increase	29.9	29.4	28.9	28.9	28.5	28.0	27.4	26.9	26.6	26.2	25.9
Students: One percent increase	21.2	21.5	21.6	21.6	21.5	21.5	21.4	21.4	21.4	21.5	21.5
Off. of Ed. base data	21.2	21.4	21.3	21.3	21.1	21.1	21.0	21.0	21.0	21.1	21.1
Teachers: One percent increase	21.2	21.2	21.2	20.8	20.6	20.4	20.2	20.2	20.2	20.2	20.1
Students: One percent increase	11.9	12.3	12.6	12.8	13.0	13.2	13.3	13.3	13.3	13.3	13.2
DYNAMOD II base data	11.9	12.2	12.4	12.6	12.7	12.9	12.9	13.0	13.0	12.9	12.9
Teachers: One percent increase	11.9	12.1	12.2	12.3	12.4	12.4	12.4	12.4	12.4	12.3	12.1

1/ Source: Office of Education base data taken from OE-10030-66, Projections of Educational Statistics to 1975-76. One percent increase in students and teachers derived from appendix tables C-1 and C-2.

APPENDIX E

List of Population Groups Used in DYNAMOD II

Appendix E

List of Population Groups Used in DYNAMOD II

Appendix table E-1 contains a list of the population groups used for the DYNAMOD II preliminary report. This list will expand slightly for future reports, because Dropouts will be included as a separate category.

Only 27 age-educational categories are listed in the table. The reason for this is that the 27 categories are identical for each of the four sex-race groups, i.e., white males, nonwhite males, white females and nonwhite females, making a total of 108 groups.

The 108 group count is substantially below the possible number of 168 groups (including deaths) for several reasons. First, impossible combinations such as "0-4 year old college students" were removed. Second, some categories, such as "44 years or older elementary school students" did not appear on the Census Bureau's data tape and their small numbers did not seem worthy of the special efforts that would be necessary to include them. Finally, a special cross-classification of deaths did not appear to be warranted, so deaths were aggregated only by sex-race category.

It was mentioned in the body of this report that 656 transition probabilities were used to estimate the population groups' crossflows. The probabilities are not presented in this report because they are so numerous and also because many will be changed slightly as a result of making the adjustments for future reports. The probabilities used in the future reports will be incorporated in those publications, or will be made available to any persons desiring them.

Appendix table E-1.-List of population groups used in DYNAMOD II, by age and educational category

Age	Educational Category
0-4	Elementary School Student
0-4	Other
5-14	Elementary School Student
5-14	Secondary School Student
5-14	Other
15-19	Elementary School Student
15-19	Secondary School Student
15-19	College Student
15-19	Other
20-24	Elementary School Student
20-24	Secondary School Student
20-24	College Student
20-24	Elementary School Teacher
20-24	Secondary School Teacher
20-24	Other
25-44	Elementary School Student
25-44	Secondary School Student
25-44	College Student
25-44	Elementary School Teacher
25-44	Secondary School Teacher
25-44	College Teacher
25-44	Other
44 and over	Elementary School Teacher
44 and over	Secondary School Teacher
44 and over	College Teacher
44 and over	Other
44 and over	Deaths